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University of the State of New York

# High School Department

Bulletin 2 November 1899

## New York State Science Teachers Association

## PROCEEDINGS OF THE THIRD ANNUAL CONFERENCE

Held at Columbia university, New York city, 29-30 December 1898

INCLUDING

Proceedings of the first and second annual conferences

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# High School Department

Bulletin 2 November 1899

## New York State Science Teachers Association

## PROCEEDINGS OF THE THIRD ANNUAL CONFERENCE

Held at Columbia university, New York city, December 29-30, 1898

INCLUDING

**Proceedings of the first and second annual conferences**

## SUMMARY OF SESSIONS

**Thursday, December 29, 9.30 a. m.**

Meeting of executive council

Registration

Opening session; called to order by Prof. Edward L. Nichols, *chairman.*

Address of welcome
Pres. Seth Low, Columbia university.

Response
Prof. Edward L. Nichols, Cornell university, retiring president of the association.

Introduction by Prof. Nichols of President-elect Prof. Charles W. Hargitt, Syracuse university.

Zoology as a condition for admission to college
Dr Charles B. Davenport, Harvard university.

Discussion:

Prof. Edwin G. Conklin, University of Pennsylvania.
Arthur E. Hunt, Manual training high school, Brooklyn.
Prof. James E. Peabody, Boys and girls high school, New York.
Prof. Charles W. Dodge, University of Rochester.
Dr Henry A. Kelly, Ethical culture schools, New York city.
Charles B. Scott, Oswego normal school.
R. Ellsworth Call, Children's museum, Brooklyn institute of arts and sciences.
Dr Frank M. McMurry, Teachers college.
Dr Charles B. Davenport, Harvard university.

### Thursday, 2.30 p.m.

Meeting called to order by Prof. Le Roy C. Cooley, *chairman.*

Report of the committee of nine, presented by Prof. Le Roy C. Cooley.

Reports of subcommittees:

Nature study
Presented by Charles B. Scott, Oswego normal school.

Earth sciences
Presented by Prof. Richard E. Dodge, Teachers college.

Botany
Presented by Prof. George F. Atkinson, Cornell university.

Physics
Presented by Prof. William Hallock, Columbia university.

Union meeting, Schermerhorn hall, Columbia university.

On invitation of the American society of naturalists, the association united with them in their annual discussion, which is reported in full in the proceedings of that society.

Advances in methods of teaching:

Zoology
Prof. Edwin G. Conklin, University of Pennsylvania.

Anatomy
Prof. George S. Huntington, Columbia university.

Physiology
Prof. William T. Porter, Harvard medical school.

Psychology
Prof. Hugo Münsterberg, Harvard university.

Anthropology
Dr Franz Boas, Columbia university.

Botany
Prof. William F. Ganong, Smith college.

### Thursday, 8 p. m.

nual address: Science and the new education
By the president, Prof. Charles W. Hargitt, Syracuse university.

eception by the trustees of Teachers college, in the Bryson library.

### Friday, December 30, 9.30 a. m.

### Section meetings

ection A—Biology. Prof. Charles L. Bristol, New York university, *chairman.*

Introductory paper
Prof. George F. Atkinson, Cornell university.

Discussion:
Prof. A. D. Morrill, Hamilton college.
Prof. Francis E. Lloyd, Teachers college.
Dr Frank M. McMurry, Teachers college.
Prof. George F. Atkinson, Cornell university.

Physiology in the high school
Prof. James E. Peabody, Boys and girls high school, New York city.

Published in *New York teachers magazine*, Feb. 1899, v. 1, no. 2, p. 163-70.

Methods of teaching botany in the Girls high school of New York.
Miss Idelette Carpenter, Maplewood, N. J.

Published in *New York teachers magazine*, Mar. 1899, v. 1, no. 3, p. 205-11.

ection B—Earth science. Prof. Richard E. Dodge, Teachers college, *chairman.*

Physical geography in the first or second year of the high school

Prof. RICHARD E. DODGE, Teachers college.

EZRA W. SAMPSON, Mixed high school, New York city.

Miss L. BELLE SAGE, Olean high school.

Discussion:

R. ELLSWORTH CALL, Children's museum, Brooklyn institute of arts and sciences.

R. H. CORNISH, Girls high school, New York city.

Sup't J. I. GORTON, Sing Sing.

PHILIP EMERSON, Corbett school, Lynn, Mass.

Section C—Nature study. CHARLES B. SCOTT, Oswego normal school, *chairman.*

1 Aims in nature study

Higher aim: To bring the child in sympathy with nature

Prin. GEORGE H. WALDEN, School 10, Rochester.

Subordinate aim: To aid in other school work

Prin. ALICE C. KING, Teachers training school, Utica.

General discussion

2 Material for study (40 minutes)

Bird study

Mrs N. DEG. DOUBLEDAY ("Neltje Blanchan," author of *Bird neighbors*), New York city.

Insect study

Prof. JOHN H. COMSTOCK, Cornell university.

Plant study

CHARLES B. SCOTT, Oswego normal school.

Earth study

Prin. ANNA J. STONE, Binghamton.

General discussion.

Intermission (10 minutes). An opportunity to examine helpful books and work of pupils.

3 Ways of helping teachers (35 minutes)

Relation of teacher and pupil in nature study

Dr CLIFTON F. HODGE, Clark university, Worcester, Mass.

Nature study at teachers institutes
Miss MARY F. ROGERS, Cornell university.

Value and use of teachers leaflets
JOHN W. SPENCER, College of agriculture, Ithaca, N. Y.

How the science teachers of the state can help teachers
CHARLES B. SCOTT, Oswego normal school.

Section D—Physics and chemistry. Prof. ALBERT L. AREY, Rochester free academy, *chairman.*

Introductory paper
Prof. WILLIAM HALLOCK, Columbia university, representing the committee of nine.

Educational value of experimental physics as taught in secondary schools
Prof. EDWIN H. HALL, Harvard university.

Physics as an entrance requirement for engineering courses
Prof. EDWARD L. NICHOLS, Cornell university.

Proposed course in the high school
Prof. FRANK ROLLINS, Boys high school, New York city.

Proposed course and the regents
C. N. COBB, Regents office.

Should the regents syllabus in chemistry be modified?
Prof. IRVING P. BISHOP, State normal school, Buffalo.
Prof. WILLIAM HALLOCK, Columbia university.

General session.

Active method in nature study
Dr. CLIFTON F. HODGE, Clark university, Worcester, Mass.

Discussion omitted on motion of Prof. Darwin L. Bardwell, who was to lead it, seconded by second speaker, Prof. FRANCIS E. LLOYD.

Before adjournment the president called on
Prof. WILBUR S. JACKMAN, Chicago normal school.

### Friday, 2.15 p. m.

Vice-pres. Prof. JOHN F. WOODHULL presiding

Use of the microscope in secondary schools
Inspector ARTHUR G. CLEMENT, Regents office.

Discussion:

Prin. EDWARD S. BABCOCK, Portville high school.
Prof. FRED Z. LEWIS, Canandaigua high school.
Sup't J. I. GORTON, Sing Sing.
Prof. CHARLES W. DODGE, University of Rochester.
Prof. WILLIAM HALLOCK, Columbia university.
Prof. IRVING P. BISHOP, State normal school, Buffalo.
Prof. C. W. HARGITT, Syracuse university.

**Friday, 8 p. m.**

Lecture—Educational value of bird study (with stereopticon illustrations)

FRANK M. CHAPMAN, American museum.

*Adjourned*

Sketch of association with brief reports of first two meetings.

List of members, 1898.

## SUMMARY OF ACTION

### Recommendations

ADOPTED BY VOTE OF THE ASSOCIATION, DECEMBER 30, 1898

1 In general: That science should be taught continuously in all secondary schools during the four years' course and should include each of the three great divisions, according to the methods laid down in the recommendations of this report.

2 In particular: That at least one typical branch of physical science, and another of biologic science, and another of earth science, should be taught in all secondary schools, each for one year with five exercises a week, in preference to the sacrifice of either of these departments for the sake of a more extended course in any one of them.

3 That the association approve the propositions contained in the reports on nature study and secondary science courses and authorize the necessary steps to make them effective.

These propositions relate to:

The functions of science in elementary and secondary education;

The general method which should prevail in science teaching: at which combines oral instruction, textbook study and laboratory field work;

The selection of subject-matter for the work in each branch;

The distribution of suggestive outlines or syllabuses, and other eans of facilitating the work of teachers.

4 That any physical, biologic or earth science which has been ursued consecutively for one full year, by the approved classroom nd laboratory methods and which has stood the approved tests for uality, should be accepted by the colleges for admission to their eshman classes.

5 That this association through its committee of nine, or in some ther way, endeavor to cooperate with the regents of the state of ew York and the department of public instruction, the Associated cademic principals and the New York state teachers association, nd other educational agencies, in efforts to promote the interests f education by making science a satisfactory educational subject in ll our schools and colleges.

### Committees

*Voted,* That a committee of three be appointed to cooperate with the State teachers association and to render assistance if desired in the science work of the association.

The committee consists of C. N. Cobb, Prof. I. P. Bishop and Prof. C. W. Dodge.

**Narcotics.** Prof. Bishop, on behalf of the council, presented the following resolution:

*Resolved,* That a committee of five be appointed to ascertain and report what is definitely known regarding the physiologic effects of alcohol and narcotics on the human body, and to recommend suitable methods for teaching the same in the schools of this state. *Adopted.*

**Committee of nine.** On recommendation of the executive council, it was

*Voted,* To continue the committee of nine for another year.

**Meeting of 1899.** It was announced that the council had selected Syracuse as the next place of meeting and that the meeting would occur on the last day and the day following the meeting of the Associated academic principals.

### Committee reports

**Resolutions.** The committee on resolutions presented the following report which was unanimously adopted.

*Resolved*, That this association extend its thanks to *Science* for publishing a report of the proceedings of our meeting at Ithaca, December 1897, and for printing the program of our present meeting in advance; also to the *New York school journal* and to the *Journal of pedagogy*, of Syracuse, for devoting generous space to reports of the Ithaca meeting.

*Resolved*, That hearty thanks be extended to Pres. Low, of Columbia university, for his kind words of welcome and his many acts of thoughtful courtesy; to the trustees of Teachers college, for the free use of their convenient and pleasant building, and for the opportunity for friendly intercourse, afforded by the reception of Thursday evening; to the local committee for the careful and thorough preparation for our coming, and the anticipation of all our needs; and to the authorities of the American museum of natural history, for opening their great institution for our inspection and study.

DARWIN L. BARDWELL
IRVING P. BISHOP
*Committee*

**Nominations.** The committee presented the following names:

*Officers—President*, Le Roy C. Cooley, Vassar college.

*Vice-president*, Albert L. Arey, Rochester free academy.

*Secretary and treasurer*, James E. Peabody, Boys and girls high school, New York city, 3 av. and 157 st.

*Council*—1899 John F. Woodhull, Teachers college.
1902 Charles N. Cobb, Regents office.
1902 Franklin W. Barrows, Buffalo.
1902 J. H. Comstock, Cornell university.

RICHARD E. DODGE, *Chairman*

By vote of the association the secretary was directed to cast a ballot for the nominees as reported, and they were declared elected for the coming year.

### Treasurer's report

The treasurer presented the following financial report for the year ending Dec. 28, 1898:

*Receipts*

| | | |
|---|---|---|
| lance in treasury | | $0 |
| bscriptions paid in | | 72 50 |
| nnual dues paid to treasurer | | 89 10 |
| nnual dues paid to local sec., J. M. Jameson | | 45 |
| terest on funds in savings bank | | 75 |
| | | $207 35 |
| *isbursements* | | |
| pendelow printing company | 59 75 | |
| res. E. L. Nichols | 7 50 | |
| rof. Le Roy C. Cooley | 16 35 | |
| Prof. S. H. Gage. (Trunk line assoc.) | 12 | |
| Prof. H. C. Bumpus. (Second annual meeting). | 1 | |
| Sec. F. W. Barrows | 17 38 | |
| Eaton & Mains (printing) | 4 50 | |
| Buffalo postoffice | 28 | |
| Miss M. E. Webster, (clerical work) | 6 80 | |
| Local committee, Sec. J. M. Jameson | 19 15 | |
| | | $172 43 |
| Balance in treasury, Dec. 29, 1898 | | $34 92 |

FRANKLIN W. BARROWS, *Treasurer*

The auditing committee have examined the accounts of the treasurer and find them to be correct.

Respectfully
CHARLES W. DODGE, *Chairman*
J. W. FRELEY

## ADDRESSES, PAPERS AND DISCUSSIONS

### Thursday morning, December 29, 1898

**Prof. Edward L. Nichols**—It is my very pleasant duty to call to order this opening session of the third annual meeting of the association, and to announce that we are to have the pleasure and the honor of listening to the head of the institution whose hospitality we enjoy today, the Hon. Seth Low. I have great pleasure in presenting Pres. Low.

**Pres. Seth Low**—It gives me very great pleasure to welcome this association to Teachers college and to Columbia university. I suppose that this association unites with a general interest in science, the specific desire to improve the teaching of science by coordinating the work done in the various schools and academies and colleges of the state, and to improve the methods of teaching by giving information as to improvements that have been brought about in any part of the state. I presume that the battle has been won, so far as the admission of science into the schools as a proper subject for study is concerned, and that now your problem is not so much the broad question as to whether science can be taught, or should be taught, at various stages of the student's career, but it is rather the more specific question of what should be taught and how it should be taught. I think that the importance of the knowledge of how to do a thing is very well illustrated by an anecdote that may be familiar to many of you. I remember reading of a manufacturer in New England whose factory was brought to a stop because a certain pump failed to work. His own engineer was unable to mend the pump; and, finally, they sent for some one in the neighborhood who had the reputation of being a clever mechanic. He came and looked at it, walked all around it, asked for a hammer and struck the pump a blow at a certain point, and immediately the pump resumed its normal function. When the manufacturer received the bill he saw that he was charged $25.50; and his first feeling was one of immense indignation. He sat down to write a letter declining to pay such a sum for such a service; but before writing the letter he read the items of the bill, which were as follows:

| | |
|---|---|
| For fixing pump.................................. | $ 50 |
| For knowing how................................. | 25 00 |

and he immediately sent his check with a letter of thanks and appreciation. Now it is not less important to know how to teach science than it is to know how to fix a pump, and therefore the service which such an association as this can render to the cause of education in this direction alone, not only in New York state but throughout the country, is beyond question.

A college or university president needs to know only two things; one, what he does not know; the other, who knows it. I know, for ample, that I do not know how to teach science; and therefore I all not undertake to speak now on that question. I simply want emphasize this fact which perhaps even a college president is titled to know, that a good teacher must continue to be a good arner. The moment a teacher ceases to learn, constantly and conientiously, that moment, I think, his value as a teacher begins to ll. That is the spirit in which every teacher should approach his wn subject. This is just as true of the teacher in the primary rades, whose equipment may be supposed ample, as it is in the niversity. It is not so much the energy of the man or his knowldge which is important, as it is the temper of mind. The attitude f mind is the vital thing whether you are to teach the young child r the mature student, and that is the spirit in which you should be ere in order to profit from such meetings as this. You must be illing to learn, ready to learn; for it is in that spirit that you may lso hope to give information which may be serviceable to others.

I need not say that it is a great pleasure to us of Columbia to have this association meet under this roof. We hope that you will enjoy yourselves so well that you will come again. I believe that the annual address of your president is to be delivered this evening in the chapel of this building on the first floor, at 8 o'clock, and immediately after that a reception will be tendered to the association by the trustees of Teachers college. It is hoped that you will all find it a pleasure to be present on both occasions.

**Prof. Edward L. Nichols**—Permit me on behalf of the Science teachers association to express the pleasure which we all have in being welcomed to these halls by Pres. Low. This association, as you know, is young; this is our third meeting. The State science teachers association has a great work to perform and will have in the future many functions as yet hardly recognized. Pres. Low has just spoken of the importance of learning how to teach science, and by our discussions we hope to help each other. But we have more than this to do if the association fulfils its aims. In the first place we hope to bring together in a close association of fellow workers, the science teachers of this state; and we have come to New York this year that we may gain the sympathy and secure the cooperation of science teachers of this neighborhood. Therefore the Teachers college of Columbia university is a most fitting place in which to hold our annual meeting for 1898.

As time goes on and this association grows in strength and in numbers, it will have to deal with many problems other than the mere discussion of methods of teaching. It is already seeking to solve some of these through its committee of nine, which has been manfully laboring these two years. Science in the schools is very young, and its condition even now may be called chaotic. There are many striving to teach science in the schools, there are some teaching science well in the schools; and yet one need not go far to find that there is a very great difference of opinion regarding the things to be taught; one need not go far to learn how wofully inadequate is the time allotted to science teaching in the schools as compared with that which is given to the languages and to mathematics; one need not go far to see how inadequate is the equipment with which science teachers have to work.

We have in this association an earnest and determined set of men and women, who love science, who know how to teach science, whose enthusiasm for their fields of work is certainly worthy of the very highest praise. Now the chief purpose of the organization, at least for the next few years, should be the calling together of these kindred spirits so that they may make their enthusiasm and their skill as teachers felt by the public—the pedagogic public first of all, the greater public afterwards, in order that science may have the recognition and the opportunity which it deserves. Elbow room is what we need for science in the schools, and if this association moves on in the direction in which it is now pointing, it will secure room in which we may carry on our work, money for laboratories and for the furnishing of laboratories, time in which to do the work which we all desire to do and are eager, willing and anxious to do.

I can not speak in detail of the many things which we science teachers hope to accomplish through this association. These will come up one after another. This year we seek among other things to get into sympathy with, to gain the cooperation of the science teachers of this section of the state. The Teachers college, by offering us hospitality, has helped to make this possible, and on behalf of the Science teachers association I beg to thank most heartily Pres. Low and those whom he represents.

And now my opportunity to serve you draws to a close. I deem a great honor as well as a great pleasure to have been permitted to rve the Science teachers association by presiding at one of its nual meetings. I beg now to introduce Prof. Hargitt of Syracuse iversity, to whom as the new president of the association, I resign e chair.

**Prof. Charles W. Hargitt**—It is my very great pleasure to acnowledge my obligations to the science teachers for the honor that ey have extended to me. I shall not now go into any details as to e work of the year or the plans for the future, further than to call our attention to what has been done during the year. The program largely organized about one primary purpose. Two years ago here was appointed a committee of nine to whom were referred ome two or three fundamental propositions which early pressed hemselves on our attention. This committee made a preliminary eport last year and will make its final report at the present session. Our program is organized around what will probably be the recomnendations and the center of interest in this report.

In the work of the council during the year there have been three meetings and extended correspondence on the preparation of the program. This work has been singularly successful in having secured the interest and active cooperation of several members of other scientific societies, and this satisfaction is abundant compensation for our labor. It is therefore with very great pleasure that I introduce to the association Dr Charles B. Davenport, of Harvard university.

## ZOOLOGY AS A CONDITION FOR ADMISSION TO COLLEGE

BY DR CHARLES B. DAVENPORT, HARVARD UNIVERSITY

In opening the present discussion I propose to maintain that zoology is a proper subject to be offered for admission to college. I shall also attempt to outline my conception of the best kind of secondary instruction in zoology.

The first question is, May zoology properly be offered for admission to college? Any subject which may properly form part of the curriculum of the secondary school program should be usable for admission to college. The college is not only for those who, from an early period, have been specially fitted to enter it; any high school course of adequate scope and content should lead up to the college gates. A second reason is that the college can elevate the standard of teaching in any subject by conditioning students who have been poorly taught in that subject. The question whether zoology may properly be offered for admission to college consequently depends on the answer to the question whether it properly forms part of the secondary school curriculum. Here we must distinguish between the classical schools and the English schools. The classical schools have a program which, established in its main features in medieval times, has only recently, with many misgivings, admitted a single science and this science is doubtless preferably physics or chemistry. The English schools, on the contrary, have room for two or more sciences and here zoology may reasonably hope to find place. The English school program, while it should lead to college, is specially arranged for the future average citizen, the business man, the man of affairs, rather than for the professional scholar or even the intending college student. The question then arises, Is zoology of such importance to the average student as to warrant placing it on the program, rather than some other aspirant for the place? I think it is if appropriately taught. This teaching should include training in analysis and careful observation; it should include also information which shall give insight into those large matters of the origin of human structure and habits which every citizen should know. The appropriate teaching should cultivate moreover that sympathy

> Not with the mean and vulgar works of man,
> But with high objects, with enduring things,
> With life and nature—

which every true naturalist has had awakened in him at some time of his life. We often hear from those that decry the study of science that the proper study of mankind is man, but we believe with Wordsworth

> One impulse from the vernal wood
> May teach you more of man,
> Of moral evil and of good
> Than all the sages can.

This sympathy with nature which comes from an acquaintance th animals opens to the student a new world beyond the social, lustrial world—a world where he can find in seasons of recreation olesome enjoyment. We Americans too often lack the training ich would enable us to enjoy nature. On summer holidays peo-e flock from the city, some to gather in as crowded, if cooler, aces of amusement; others to organize a "side-hunt," whose aim to kill animals promiscuously for "points." Only a few find easure in roaming in an orderly way along roadsides or through e woods in the real country. The well-to-do business man who tires for his vacation into the country finds it uninteresting. He efers the hotel veranda where he can read the newspaper and dis-ss politics and the market with fellow vacationists. How dif-rent are our habits from those of the German people, who have een taught natural history in their school days and have thus quired an interest in nature which they retain throughout life. n holidays they wander with their families away from the crowds ut into byways, meadows and woods, there to renew their acquaint-nce with plants and animals. Can we question that this habit is nore conducive to physical, mental and social health? The centri-etal tendency of our people, who flock to the cities, and in the ities gather in clubs, lodges and saloons, is partly accounted for by lack of appreciation of the free wealth of beauty and interest that the open country affords. Anything which brings our people to appreciate nature, which awakens a love for it like that of a child for its mother, will help stem these disastrous migrations. The study of zoology then combines the training of the other sciences with important information of its own and has a peculiar moral effect of great importance. Now I contend that a subject whose study may affect the student in so many ways has an almost unique educational value and consequently deserves a place in the high school program.

The question now arises: what is the best method of teaching zoology so as to bring about these results? In certain other subjects, the classics, mathematics, even physics, a best method seems to have been practically agreed on. At least there is widespread agreement in methods among the best schools. In the teaching of zoology in secondary schools there is, on the other hand, very great diversity. But there is agreement on one point—in studying zoology the pupil should study animals—not merely *about* animals. We all believe in laboratory work in zoology nowadays; we have been believing in it more and more since the days of Louis Agassiz, but we are not unanimous as to what it should be. The most popular single method is that of detailed anatomic study of types, introduced in 1875 by Huxley and Martin in their *Elementary biology*. At least we may judge that it is the most popular method if there is any criterion in the large number of laboratory guides following this method which are published and presumably sold. The names of Boyer, Bumpus, Colton, Dodge and so on through the alphabet, will recall some of these laboratory handbooks. No one can doubt that Huxley's method has been found valuable in the secondary schools, but it does not therefore follow that it is the best for American high schools today. It has had its place in the past. It is an easy laboratory method to administer and on this account has gained greater headway than a more difficult one would have done. I for one hope it will now gradually disappear from the high school and for two reasons: first, its presence leads to confusion in the education system, and second, it is intrinsically not most fitted to secondary instruction.

The confusion of which I speak is due to the fact that a similar course in invertebrate anatomy is the introductory course in most colleges. We find such a course here at Columbia university, at Johns Hopkins university, at Harvard university, at many of the smaller colleges of the state of New York. This course is a necessary introduction to advanced collegiate courses in embryology, histology or physiology; it can be done better in the college with its more abundant illustrative material, with more specially educated teachers and with maturer and more rigidly selected pupils. The course has indeed gotten into the high school because college-bred men having to organize a high school course in zoology naturally tried to reproduce in their school the elementary course that they had studied in college. What is the result? Confusion and an overlapping of work. Only recently a student came to Harvard to take up graduate work in zoology and wished to know where he should begin. He had had a course in zoology à la Huxley in the high school, and again a course à la Huxley in the college and hoped he might be spared the course à la Huxley in the university.

he had been regularly taught in zoology was the dissection of es. This case is an instance of the unfortunate state of things in zoologic system of instruction. The college can hardly be called to give up its course in invertebrate anatomy; there is no need .t it should. There is a better field for the high school to culti- :e; one better adapted to the need of the future average citizen.

Let us now look at this better secondary school course in more :ail. First, it is not necessary to argue that the backbone of the urse should be laboratory work. The students must handle ani- ıls and study them at their desks, but not at their desks only. They ould collect invertebrates and make such studies on them in the ld as they can: at first in company with the teacher, who will show em what to look for and how to find it, and how to make field ›servations; later, alone or in groups, stimulated to compete with ıe another in collecting and arranging specimens or in making re- ›rts on field observations. Who can doubt that the boy who col- cts grasshoppers in the autumn, observes the winter habits of birds, nd makes notes on the first appearance of spring insects will, in onsequence, develop into a more wholesome and useful man?

But this first hand work should be supplemented by oral instruc- ion from the teacher or by the study of a textbook or of numerous eference books, for it is important that the citizen know some- hing of the literature of the sciences. Moreover verbal instruction s necessary to the rounding out of the student's knowledge of any ubject. After he has studied a type he should be told about related ›rganisms. I advocate particularly teaching something of eco- ıomic zoology, for high school students, as future men-of-commerce and legislators, should be informed on the relation of animals to man.

The backbone of the course must, as I have said, be laboratory work; indoor laboratory work, and such as can be done in 45-minute periods. This time should not be spent in dissection but as much of anatomy as can be learned without the aid of dissecting instruments should be studied. And this is a great deal. Among the insects and crustaceans most of the important structural features which separate the orders from each other are revealed on the exterior. By simple manipulations, such as breaking away the carapace of the crayfish or removing the shell of the clam, additional organs are exposed, without special dissecting apparatus.

There are reasons besides the larger ones I have urged at the beginning, for confining the anatomic study to the external organs. In the time saved from dissection a larger number of types may be taken up. For instance, to the crayfish may be added such other crustacea as a sow-bug and a water flea. The study of the exterior is of great consequence because on it are left the most important records of adaptation to surroundings. It is of special importance to the citizen because it is that which he sees in the park or country. He does not go about with knife and forceps, but if he is interested he will note the form and markings of the elm tree beetle that lights on his coat in the street car and get out of it much mental enjoyment.

The needs of the future citizen should determine the kind of animals to be studied. They should be those which he will be most apt to meet with out of the laboratory. In the interior of our country these will be chiefly land and fresh water animals. The types should be large enough to be studied with the naked eye or with the aid of a hand lens. I do not question that it is an interesting and valuable experience for the future citizen to know something at first hand about microscopic organisms; I should be glad if each one could draw an amoeba or a paramecium. But I think it is more important for a school to be equipped with proper aquaria, charts and books than to have a compound microscope for each student in a laboratory section. A few good microscopes are almost indispensable; but it seems to me that teachers are too often allured by agents of microscopical firms into buying sets of expensive microscopes, microtomes, paraffin baths and other histologic apparatus which are out of place in secondary instruction.

In addition to external anatomy I advocate the study in the laboratory of such activities of living animals as locomotion, response to stimuli, the feeding and repiratory movements. This physiologic study is as important as the morphologic study, as practicable for the schoolroom, as capable of precise observation and record, and to most students more interesting. I advocate simple experiments dealing with normal reactions, and having no element pain. They teach the student that even the lower animals are tient and give him a greater regard for their life and happiness. an not here go into details. Suggestions for observations on living animal, including experiments on the normal reactions, l be found in an *Outline of requirements in zoology for admis-n to the Lawrence scientific school of Harvard university.* Such dies as are suggested in the outline have been carried on for o years by Dr Linville in the boys high school in this city with ccess. Now I imagine there is not in the country a less favor-le place to get living invertebrates for study than W. 13 st. New ork city, in the winter time. The difficulties of getting living aterial for winter work need not therefore dissuade a teacher from e sort of work here suggested.

To sum up, zoology should be usable for entrance to college be-use it is a desirable high school subject and because the instruc-on in this subject in secondary schools can be improved by the rutiny of college examinations. The proper method of teaching e subject avoids the time-consuming details of internal anatomy nd seeks first to interest the student in animal life. Specially those nimals and parts of animals are studied which are not far removed rom daily experiences. Animals are studied as they occur in the ield and field observations and systematic study are encouraged. They are studied as living, sentient beings, and are considered in elation to man. Such a line of study if commonly pursued in igh schools would create in the next generation a wider interest in ature and conduce to improved moral sanity.

**Prof. Edwin G. Conklin**—" So much has been said and so well said " that it practically leaves me without anything to say. I agree with what Dr Davenport has said in almost every particular and consequently if a contrary opinion is looked for you will all be disappointed. When I first read the title of the paper to which we have just listened, " Zoology as a condition for admission to college," it occurred to me that it might signify a requirement for admission. Of course that has not been the position taken by Dr Davenport, nor, I dare say, the position which any of us would care to take. There are a great many reasons why zoology ought not to be required for admission to college. One is that it is not necessary as a preparation for the zoologic work of the colleges. It is very useful but as Dr Davenport pointed out, the leading universities of the country now give general zoology courses in which they deal with the fundamental facts and principles of the science. Such work forms a good introduction to zoology and could not well be omitted by the colleges even if there were an entrance requirement in this subject.

This subject, like most others, must be looked at from both the college standpoint and that of the secondary school. We of the colleges do not desire the high schools and the grammar schools to be little universities and colleges. The extent to which this mistake has been carried by many well-meaning teachers is very great. I have heard of a high school where an attempt was made to introduce journal clubs and seminars and the teacher talked seriously about research work in zoology. Of course his ideas concerning a course in zoology were derived entirely from university courses and he was not able to adapt himself to the needs of those whom he was called to teach. We who teach zoology in the college would like to have students prepared for our work, not by exhaustive anatomic study but by a course which will give some breadth of view with regard to the animal kingdom. I have in mind a high school in which the study of types was carried to this extreme; in the entire course two animals only were studied, two invertebrates, with the idea, as the teacher suggested, of knowing everything about these animals. In the end the pupils did not know everything about these animals any more than the teacher or anybody else did. There is no limit to any subject and the wise thing to do is to make somewhere an artificial ending of the work on a certain type and go on to something else. The greater part of the time spent in laboratory work is commonly in minute dissection. Work could be so done, if limited to external morphology and to the general physiology of an animal, that it would not be slipshod and yet a considerable number of animals could be studied. The future citizen does not want to know merely an earthworm and a crayfish. There are a great many interesting and profitable things to know about many different animals, and he ought to have some breadth of view with regard to the whole animal kingdom.

s to the method by which the work should be taken up, no
e can plead that it should be other than a study of animals them-
ves. I am sometimes sorry that our science is called by a name
ich might suggest, and possibly does suggest to some people,
e idea that it is a discussion. The *logos* part of it gets very
ominent in the minds of some people. I was looking over the
talogue of a prominent private school in this state and found that
e science teaching was put down in this wise: " Lectures on such
d such a subject throughout the year. The student is required
take notes and the notebooks are rigorously examined." That
a very common idea, I imagine, with regard to zoology, but it
absolutely wrong. We do not want to know writings about ani-
als, we want to know animals; we want to know their habits,
here to find them and how they live, something about them that
ill arouse our interest and sympathy, something to make us feel
at these humble creatures are sentient fellow-beings. When we
ave done this we have aroused that emotion which Coleridge so
eautifully expresses in the lines:

> He prayeth best who loveth best
> All things both great and small.

So I would argue, as Dr Davenport has done and in almost ex-
ctly the same words, that so far as the colleges are concerned what
e need is differentiation of work. Do not attempt to repeat the
niversity work in the high school but give another and very dif-
ferent type. On the other hand there is the high school side to be looked at, and that is the important side, for what the colleges may need or may not need is practically a very small matter to the high schools. I think about 1% of the graduates of the high school go to college and it would be absurd for the high school to be forced into giving certain things simply to meet the requirements of 1% of the students who go through its courses. The colleges must come to the standard of admitting students who go through high school courses fitted to make future citizens, and we may depend on their philosophic spirit to see sooner or later that those subjects which best fit a man for life best fit him for college. The question is, Can we in any way show that the subjects which best fit a man for life best fit him for college? I think

that the type of work which has been presented by Dr Davenport and for which I am speaking, is the type which best fits a man for life, and, as we agree, best fits him for college.

But there are other biologic subjects which must be taken into account, and if the secondary school is so limited in time that it can give but a very few weeks to the consideration of biology, I should by all means recommend the study of physiology—not the old type of textbook physiology nor a course requiring an extensive knowledge of anatomy, histology and chemistry, but one between these two in which the pupil shall get some knowledge first of human physiology and second of the laws of health. This is the most useful subject in biology which the future citizen can take up, and if no time is to be had for zoology, I think we ought first to teach physiology as unquestionably the important thing. It is certainly more important to know something of the life and nature and habits of man than of an amoeba or grasshopper.

**Arthur E. Hunt**—If I had not already been convinced that the scheme which Dr Davenport has outlined of presenting the subject of zoology is in the main the best for secondary schools, I should now be convinced. I would particularly second what he has said concerning the study of the living animal. This very necessary part of the subject of zoology has been sadly neglected. The reason is not far to seek. In many cases teachers are not prepared to take up this part of the subject successfully; then too, the difficulties of presenting it in large classes are not inconsiderable. But I believe these difficulties may be largely overcome and they must be if we are to secure the best results.

But the difficulties that arise on account of the attempt to work with living material are not the only ones which the teacher of zoology in the secondary schools must face. When I began my work as a teacher of science, I attempted to answer this question: Can zoology be taught in the secondary schools in such a way as to make it a genuine discipline which may be favorably compared with that secured by the teaching of geometry, Latin or physics? I found that physics and chemistry had been well taught, but zoology and botany were still considered merely information subjects and treated accordingly. Therefore there were no laboratory ilities, no reference books, and the time assigned the subject was ufficient.

One by one these difficulties were overcome. The equivalent five hours a week for 40 weeks was secured. A well-lighted om was set aside and properly fitted up for a laboratory, and the aid of students a number of reference books were purchased. rtunately, from one point of view at least, I taught several other bjects, which made it possible for me to institute some interesting mparisons. These comparisons proved so favorable to zoology at I have never since had any doubt of the great value of the subct as a disciplinary means.

It should also be said that I had comparatively few students of e better class, for obvious reasons. In fact, I felt obliged to adse students who had any idea of preparing for college not to take e subject. But there were always some students who would deide to prepare for college in the last years of the course. I had few such who had done first-class work in zoology, botany and hysiology who were obliged to take an additional year in the chool, though in the best sense of the word they were already repared. This led to a feeling of injustice on the part of the stulents and also injured the standing of zoology and botany in the chool. I had overcome other difficulties, but here was one I ould not overcome. This experience led me to believe thoroughly what Dr Davenport has already expressed, that any subject suitable for the secondary school should be accepted for admittance to college.

While I believe that the efficiency or non-efficiency of zoology as a disciplinary means will largely depend on the teacher, and that the secondary schools may secure good results working independently, yet with the cooperation of the colleges the standard of excellence can much more easily be raised and the desired efficiency be more nearly approached. This has been the result of cooperation in other subjects; why not in zoology?

**Prof. James E. Peabody**—When Dr Davenport suggested to me, about two years ago, this plan of teaching zoology, I confess that I was not a little skeptical as to whether it could be carried out. It seemed to me that work on living animals, specially in large classes, would be merely a source of amusement; I doubted whether there would be sufficient educational value in that sort of study; and so far as I knew there was no textbook at all adequate which we could put in the hands of the pupils. Now I am more than ready to acknowledge, after a year or two of experience, that I am surprised at the possibilities in this method of teaching.

Dr Davenport has certainly done one great thing for zoology. He has shown that we can study animals as they exist in nature. Most of us teachers have been trained in colleges where we carried on laboratory work, as has been suggested, that is we knew laboratory work only as dissection. Now when we come into our high school classes we try to carry out that same method with high school pupils. We give them a starfish to dissect; they go at the work in a bungling fashion, they get discouraged, and we perhaps get discouraged. I am sure that the study of external anatomy offers far better opportunities for instruction in the high school. We devoted last year 16 recitation periods, for example, to the study of the crayfish, discussing life-habits, homologies, variations, means of protection, structure and function of sense organs; internal anatomy was omitted altogether, and the pupils were wonderfully interested from beginning to end.

Another point Dr Davenport has emphasized is the study which ought to be carried on in the fields and parks. It is true this is somewhat difficult in a large city like New York, yet I have found it practicable and well worth while to take our classes, numbering 30 or 40 pupils, out into Bronx and Crotona parks. The boys and girls thoroughly enjoy these excursions and gain not a little knowledge of animal-life. Another opportunity which ought to be seized in a large city is that afforded by museums of natural history. I have found it possible for the teacher, by the use of a definite outline, to direct at the museum a company of 50 pupils in enthusiastic study of skeletons, echinoderms or sponges.

The lack of a good textbook presents a great difficulty. But I find that the teacher can impart most of the necessary information not found in the textbooks by means of talks in the class room. If the pupils are required to hand in written reports of these talks, the knowledge is fixed in their minds, and the writing is a splendid training in English as well.

I believe this suggested plan of zoology teaching will be modified some respects. For example, some of the experiments in taste d smell with negative results might well be omitted, for the pupil ways expects definite and positive results; if they are negative, he inks he has failed in the experiment.

**Prof. Charles W. Dodge**—As I happen to be the author of one the laboratory manuals of which Dr Davenport disapproves, this ay perhaps be an opportune time to explain why the "type sys- m" of instruction was adopted and to offer excuses, if any are eded, for following it. I had four years of high school experience hich made it evident to me at least that this system is the best e to use. My college experience corroborates this. The reason r adopting this method of instruction was primarily the fact that e greatest teacher of biology whom the world has ever seen, rof. Huxley, found from his experience that it is the best method use in teaching elementary classes. A more important reason that usually a single term of 14 to 20 weeks is all the time the upil has to devote to either zoology or botany. We can not ex- ect to study all the plants or all the animals in this brief time. hen the question arises, how can we give the pupil a fairly general dea of either of these groups of organisms? And, how, too, can we each him a good method of study? Shall we in zoology, for ex- mple, take only one or two groups, as the insects and the mollusks, nd spend all the time on them? Or, shall we take as good a epresentative as we can from each of the subkingdoms and study it as thoroughly as the time will permit? The former method seems to me to be altogether too much like specializing before the pupil has acquired any broad foundation on which to base his knowledge. The second method, the study of "types" so-called, gives a broader general view and exactly as good discipline. It makes very little difference whether one or several species of a group be studied. The work will be a study of "types" in either case. If the pupil examines a fly, a beetle, a butterfly and a locust, he studies these as the representatives of some of the different orders of insects, and nothing but an exhaustive examination of all the species of insects will prevent his work from being anything else than the study of "types." Personally I prefer the elementary pupil to have a broad and general idea of the different groups of animals rather than a more intimate knowledge of a few special groups whose members may be easy to collect, pretty to look at and interesting to watch, but which do not represent the animal kingdom in its broader significance.

Then, again, what shall be done with reference to dissecting, to studying internal anatomy? Dr Davenport believes that the examination of the external parts is usually sufficient. I do not agree with this view. If we are to understand the plan of structure of almost any animal or plant we must dissect it. There is little to be learned about the structure of an earthworm, for example, unless the internal parts be studied. Then, the pupil can see for himself the digestive, circulatory, nervous and other systems and get a clearer understanding of the relationship of the earthworm to other forms. I do not believe that all of the pupil's time should be given to dissection by any means, but enough of this work should be done to show the more important internal organs of every animal studied and the gradations of structure from the lower to the higher forms should be pointed out in order that the pupil may have some rational basis for a clear understanding of the elementary principles of evolution.

As regards physiologic experiments, it is evident that as much as possible should be done in this direction but it must be borne in mind that the teacher in a city school is likely to be very much hampered in such work. Observations on living animals must be confined usually to what can be seen in caged specimens, for there is seldom an opportunity to take a class to the fields and woods for a half day without interfering with classes in school or with music, dancing, drawing and other lessons or with household duties which occupy the pupil after school hours and on Saturdays. Physiologic experimentation according to university methods is neither possible nor desirable at this stage of instruction.

Then, too, I believe that our method of instruction should be such as will give the pupil a thoroughly sound and scientific method of study. It is no doubt very entertaining to watch grasshoppers jump about in the laboratory and to see how animals in an aquarium behave and much can be learned in this way. However, recreation and amusement are not the chief ends to be sought in the study zoology; rather a clear conception of the more important facts the structure and life of animals and a habit of thought and of udy which will fit the pupil to take a rational view of things in ter life. Our work should be placed on a really scientific basis › that it may compare favorably with that done in physics and in ıemistry.

Finally, in carrying on our work as teachers we may make all ›rts of attractive plans but we shall find that in every case the leal must always be sacrificed for the practical, not only in the :hool room but also in the preparation of textbooks.

**Dr Henry A. Kelly**—I am particularly interested in the prob- m of nature study in the elementary school. It seems to me that ıe arguments presented by Dr Davenport and those who have fol- ›wed him apply with particular force to this problem. Much of ıe zoology work which he suggests for the high school should nd a place in the elementary school as nature study. In those ırlier years the child's interest in observations on living animals considerable, and such work is particularly adapted to his powers f observation and generalization. Both from the pedagogic and :ientific points of view all that Dr Davenport hopes of this work ı the high school, and more, will be gained by its introduction into ıe elementary school.

For the high school let there be some dissection of type forms nd some work with the compound microscope. Dissection, even ı the rough manner in which it must be performed, is valuable, if ıe forms to be studied are carefully chosen. The fish is an excel- :nt form for study. It is comparatively simple and it offers a good tarting point for a study of human anatomy and physiology. I ›ould, of course, include as well a study of the living fish as of its natomy. The compound microscope in some such simple form as ıat suggested by Prof. Bergen in his *Elements of botany* should be sed. Its manipulation requires care but is not beyond the power f the pupil. It opens a new world to him, on which he will be ager to enter after his preparatory study of structure and function ı the gross.

**Charles B. Scott**—This seems to be a sort of experience meeting. \s I was listening to Dr Davenport's paper I was thinking of the work in zoology as applied to the university where I spent some hundreds of hours in dissection. Naturally when I went into the high school I did exactly as I had done in the university; I had my pupils dissect all the time. I discovered very soon that with children we can not work that way at all and felt that the children had to study the life side of nature. After five or six years with children I went back to the higher students and I was very much surprised to find that what I had learned with the children applied to the older students. One of my students in the normal school came to me and said, " Since I have been studying some living animals, I have learned to look at them in a different way. When I went out of doors I saw before only the trees, but they mean something more to me now." And so I find that both the younger and older students get very much more out of their science if they study the life side of it.

There is another point. Those who are going to teach nature studies in our elementary schools must get a large part of their education from the high schools. I find from my work that nine teachers out of 10 think that it means taking things to pieces. If we are going to have any real nature study in the lower grades, we must have this kind of work that Dr Davenport suggests and recognize it in the scheme.

**R. Ellsworth Call**—The discussion seems to have taken a peculiar turn, contrasting on the one hand external observation solely and on the other internal anatomy. I have had some 18 or 20 years' experience in teaching these subjects in high schools, and even now I do not know that I am yet in a thoroughly satisfactory state of mind. I can not exactly agree with the first argument which Dr Davenport advances. Inasmuch as secondary teachers, as a rule, have to do with a large proportion of boys and girls who never go to a university, it does not matter to them what the university course may be, or whether it in any sense duplicates the work of the high school or not. I have had some experience—speaking now on the necessity for some knowledge of internal anatomy—in studying with pupils the great classes of fresh-water mollusks. The student who is studying an object from any of these classes for the first time always points to the *foot*—what it does, how it acts—which fact necessitates the opening of the shell and some her study of internal anatomy. I remember an experience I l some years ago at Far Rockaway with some boys who had nd some large specimens of the *Natica heros*, a large univalve, -water mollusk. We took it up, but almost before we could the animal under observation the foot had been retracted. Now, uld we let our observation of that animal end with counting the orls and studying the form of aperture or should we go a little ther? Should we not look at the animal inside? These quesns are such as occur to every teacher of biologic science who nts to do the most for his boys and girls. I am in hearty symthy with most that Dr Davenport has said, but I think that upled with this observation of habits of life in the field, in the eam and in the laboratory vivarium, there still should be some the old-fashioned type-study of the gross internal anatomy.

In the high school the problem is simply to adjust to the usual gh school period of time the proposed work on the internal anamy and external observation. That problem has yet to be solved. believe that by cooperating with the university professors the structors in the high schools will by and by solve that problem. have to change my course of work each year. I change it to it the capabilities of the students who come to me. My classes e not the same in age and in intellectual ability each year. They ome from schools where they have been better trained some years an in others. I find, too, that environment enters into the roblem. The birds in central New York, for instance, are quite ifferent from the birds here (New York city) and nature work r zoologic work must adjust itself to one's environment in such espects. There can be no plan the details of which can be of niversal application.

**Dr Frank M. McMurry**—I would like to inquire of Dr Davenort if he would admit that the plan of work which he suggests s less scientific than the work which has heretofore been done.

**Dr Davenport**—In reply to this interesting question I would ay that I certainly regard the plan as outlined as thoroughly scienific. I regard this work with the lower animals not as ordinary ature study as I have seen it carried out in the schools, but a tudy far above that and of scientific grade. At the present time several students in the graduate school of Harvard university are doing research work on the study of the activities of these lower animals. There is now one man studying the movements of the slug. Any one who has placed a slug on a board or a glass plate may have noticed that the slug when placed on the horizontal board will move away from the light; when placed on an inclined board will move either up or down. The student is spending a good part of his year in trying to discover what it is which makes the slug sometimes go up and sometimes go down. That I regard as a thoroughly scientific problem.

I would like to say one or two other things in regard to the criticisms made by practical teachers in the high school. First, in regard to the study of types. With Prof. Dodge I believe thoroughly in the study of types. It was merely the anatomic study of types which I objected to, because it takes so much time which to my mind can be better spent in other ways, the other ways being the study of a few more types and their activities; the study of additional types being always with reference to their external parts rather than with reference to their internal structure. Reference has been made to the snail. I would advocate in this case the study of a live snail, in which one sees the essential external parts of the animal fully exposed to view. One learns, for example, very much concerning the mechanism of the tentacles by the act of retraction. Indeed, I think one learns altogether a greater variety of things and learns them in a more important way in the study of the exterior of the living snail than one would learn from a dead snail. It is a complicated machine, so complicated that we do not at the present time thoroughly understand the anatomy of the snail. It is a waste of time for the secondary student to attempt to understand it thoroughly.

In regard to dissection. I am not opposed to dissection except in so far as it takes up the time which might in my judgment be more profitably spent. I believe thoroughly, however, in the dissection of a vertebrate in connection with the study of physiology rather than, perhaps, in connection with the study of zoology. I think it is a very important thing for the student to study the anatomy of a fish or frog in connection with his study of human physiology.

**Thursday afternoon**

# REPORT OF THE COMMITTEE OF NINE

## INTRODUCTION

This association instructed the committee of nine at its last meet- ig, at Ithaca, December 1897, to carry out, as far as possible, the lans outlined in the preliminary report accepted at that time. In iat report it was urged, in consideration of the unsettled views of achers regarding the aims and methods of science teaching, and so the inexperience of many who are engaged in the work, that ie association should undertake to state the educational uses of ience courses, and suggest means of enhancing the usefulness of ience as an agent in education. It was pointed out that every ranch of science is represented in our association by men and omen who are not only specialists but educators; and the sugges- on was offered that a few of these members, working together, tempt to state in outline the functions, the subject-matter and the iethods of each branch in a manner to help teachers in the con- ruction of courses and the use of science for educational purposes. he committee has undertaken during the year to carry out its in- ruction on these lines.

To facilitate the work of the committee, the chairman was per- iitted to divide the members into groups, each consisting of persons hose special studies and experience relate to a particular depart- ient of science teaching. To one group, or subcommittee, was ssigned the subject of nature study, to another, the earth sciences, another, botany, and to another, physics. A small number f experienced teachers who are not members of the committee f nine accepted invitations to cooperate with the subcommittees. heir names will appear in this report in company with those f the subcommittees which they joined. By this plan, each f the sciences just named has been considered by those iost competent to define its educational value, point out right iethods of teaching it and recommend proper subject-matter or the courses—in a word, devise ways to make it more useful in he schools. It was intended to cover all the leading branches of chool science by this labor of subcommittees, but we have not een able to go so far, the most notable omissions being chemistry and zoology. It is hoped that these branches may be considered in the near future.

The committee of nine has received the reports of its subcommittees, which it now lays before the association. These reports contain the outlines of a scheme designed to make the study of science in the schools a serious and satisfactory pursuit. The committee invites a full discussion of them, to the end that they may embody as far as possible the views of this association. We offer no novel theories of education and advocate no untried methods of teaching. A practicable scheme for immediate improvements in science teaching can be based only on principles and practices approved by the majority of educators; and we ask the association to recognize and approve these principles and practices in the plans proposed in this report and to authorize an effort to secure their intelligent application to elementary and secondary science teaching.

Three subjects were originally assigned to the committee of nine: 1) the recognition of science in requirements for entrance to college; 2) science courses in the secondary schools; 3) nature study in the elementary schools. We refer to our last report for the preliminary treatment of these subjects, and now proceed to their further discussion.

### SCIENCE FOR COLLEGE ENTRANCE

Nature draws no lines to mark the stages of mental progress from the activities of childhood to those of more mature youth; the transition is as continuous as time itself and the rise to higher levels of thought is an unbroken slope. Such should the processes of education be. Elementary, secondary and collegiate are convenient terms to describe stages in education, but the advance from the lowest to the highest should be gradual and continuous. It is generally admitted that science study should be continuous; yet our present courses are lamentably fragmentary. Secondary schools, with few exceptions, are unable to recognize the science teaching in the grades below, and they find their own courses dishonored by the colleges. Such a condition is unphilosophic, besides causing waste and discouragement. The correlation of science courses in the elementary and secondary schools and the colleges is a problem of supreme importance. We believe that the adoption of the scheme of nature study proposed in this report uld solve the problem for the elementary schools, and that con- uity in the sciences pursued in the secondary schools can like- e be secured by the correlation of courses which we have out- d; yet granting this the problem is but half solved; the articula- n of school and college science remains to be accomplished. Neither the school nor the college has the right or the ability say what the other shall do. The secondary school is touched the college at one point only, while on all sides it is in living ntact with the social and industrial institutions of the country. condary schools are loyally striving to serve higher education, t they feel as never before, their responsibility to secondary educa- n, the highest attainable by the great majority of their pupils. e question for them is the nature and extent of secondary train- g, designed, not primarily for entrance to college, or the indus- ies and professions, but for the improvement of mind and char- ter, the development of which is the best preparation for both. here can, therefore, be no perfect articulation of school and college ience till the schools and colleges agree on definitions of the ms, methods and subjects of secondary science teaching. A pro- isional agreement on some fundamental points, however few its rticles, would be an important step toward the solution of the hole problem. What agency is better adapted to propose the rms of such an agreement than our association, which includes he science teachers of all the schools and colleges of the state? re not some fundamental principles, relating to the use of science n education, already accepted by the larger number of those who tudy the needs of school and college training? And if these can e stated, will they not present a basis on which the ideal relation etween the school and the college may be established? We ask he association to arrange a full discussion of this subject for its next meeting and to solicit the cooperation of all other agencies interested in the promotion of scientific study in the schools for the solution of the problem.

The ideal relation between school and college science will require an agreement by which the schools will make their science teaching conform to standards alike acceptable to them and to the colleges, while the colleges will freely accept the work of the schools as preparation for their courses. The details of this mutual understanding must be left for future discussion, but general features may be indicated now. We offer for the adoption of the association the following recommendations:

1 That at least one typical branch of physical science, one of biologic science and one of earth science be taught in all the secondary schools, each for one year, five exercises a week, by methods which combine oral instruction, textbook study and laboratory or field work.

2 That work in any physical, biologic or earth science pursued consecutively for a full year by the approved class room, laboratory or field method, which has met approved tests for quality be accepted by the colleges for admission to their freshman classes.

### SCIENCE COURSES IN SECONDARY SCHOOLS

The preliminary report of the committee of nine declared, "The sciences should be taught in the secondary schools by a method which combines oral instruction, textbook study and laboratory work, and an immediate effort should be made to establish the practice of such a method by securing the recognition of laboratory and field work in the construction of science courses, in the time allotment to science teaching, and in all tests for proficiency in the several branches." The committee took the first step in the solution of the problems set for it in the foregoing recommendations by appointing subcommittees on the several sciences. These subcommittees have considered the aims, subject-matter and methods involved in the teaching of several branches, and we now present an abstract of their reports.

**Physical geography.** The committee on earth science, in the interest of physical geography, has considered four questions: Where should this science be placed in the course? How much time should it occupy? What subject-matter should be selected? What general methods of work should prevail? Physical geography has been assigned by many educational conferences and the practice in many schools to the first or second year of the high school course. The committee of 10 in 1892 placed it in the first year. The subcommittee on physical geography of the N. E. A. consisting of representatives of six of the most prominent educaal associations in this country, has recommended that this sub- be put either in the first or second year. Numerous teachers have been consulted are of the opinion that physical geography uld come as early in the course as possible. This opinion is of our subcommittee. It recommends that a course in physical graphy, occupying at least three periods a week for one year, given in either the first or second year in every high school.

s to subject-matter, it is advised that questions of pure physics, criptive geography and biology be avoided as long as possible. propriate topics are to be found in the three grand divisions, air, an and land. The relationship of physiographic phenomena to as illustrated by the home environment of the pupils should be died, while the relation between cause and effect should be kept stantly in view. It is further advised that laboratory and d work be constantly associated with the class room exercises physical geography and that a laboratory notebook be carefully t. To assist teachers in the construction of a course involv- these purposes and methods, a complete outline of topics has n drawn up and can be found in the report. That teachers may rn to equip and use the laboratory in physical geography, a list s been made of the most available papers dealing with this im- rtant but difficult matter. It is advised that pupils be taught to reference books and that lantern slides be employed to illustrate tures of the subjects which the pupils can not see.

The recommendation is made that physical geography be placed the list of elementary subjects, such as algebra and history, re- ired for entrance to college. Reasons are given, on the other nd, why this subject should not rank with botany, physics or her single sciences as a requirement for college entrance.

**Geology.** The same subcommittee contends that, while physical ography may be placed with great advantage in the first or cond year, provision should be made for the study of earth science a more advanced course and reasons are given why geology, in eference to other branches, should be selected. Its recommenda- ons are as follows: That geology be placed in the third or fourth ar of the high school and that, whether required or elective, the ourse should occupy a full year with five periods a week. That one, or better two, of the five periods, be devoted to laboratory and field work. That textbook study be supplemented by the use of more advanced works of reference. That the chief stress be placed on the structural and dynamic aspects of the science, rather than on the stratigraphic and paleontologic as is done in the courses which prevail at present. That the colleges of the state be requested to place geology when taught for a year, five periods a week, in a list of sciences which may be offered for entrance to the freshman class.

**Botany.** The committee on botany holds the opinion that a course in this science should extend through one full year in the secondary schools, and it lays stress on the importance of a judicious selection of subjects and of the observational and experimental methods of study. A complete outline of a year's work in elementary botany is therefore presented.

In constructing this outline the fact was recognized that all schools are not at present prepared to give so long a course in this subject. Accordingly the central topics in each general subject are distinctly indicated, and such schools are advised to select those for an abbreviated course suited to their necessities. By the selection of these central topics from all the general subjects, the true relations, harmonious proportions and logical sequence of the subject-matter of the entire course may be preserved in the abbreviated work. The outline is thus made flexible enough to suit all schools which desire to do as much as possible of the best kind of work in the best way, whether or not for the present they can devote a full year to this science.

In view of the importance of experimental work in botany, and of the difficulties which beset the teacher, the topics given in the outline are accompanied by practical suggestions. Descriptions of the materials to be used are given, together with hints for finding them. Directions for the treatment of materials for the purposes of observation and experiment, with suggestions as to the essential facts to be looked for, are also offered.

The teacher is advised to prepare the pupil for each practical exercise by pointing out to him, before he begins, the special object of the work he is to undertake and by giving him general directions that will enable him to do it intelligently. Each student should

rd in a notebook an account of his work. This record should
ude neat drawings and brief descriptions of objects studied, ex-
ments made and facts observed. The notebook should be criti-
d, corrected and submitted for final examination.

**hysics.** The subcommittee on physics regard laboratory work
n indispensable part of the student's course in this science, and
eve that the value of laboratory study depends on the character
the topics selected for it, as well as on the method of work.
y have prepared a list of appropriate subjects and recommend
t the laboratory exercises in the secondary school course in
sics be selected from it.

n compiling this list the subcommittee have intended to include
terial enough for one full year of laboratory work in the best
ipped and most advanced schools. From this maximum num-
of subjects each teacher can make a selection for a course
pted to the advancement of his pupils or the time-allotment of
course.

The subcommittee believe that a list of reference books on the
jects of the course, with suggestions in regard to the method
conducting the experiments should be put within reach of the
chers.

### NATURE STUDY IN THE ELEMENTARY SCHOOLS

The preliminary report of the committee of nine presented at
meeting of the association in 1897 contained these words: "The
portance of a continuous course of nature study in all elementary
hools as an indispensable element in primary education and as
preparation for the study of science in the secondary schools de-
ands an immediate effort to formulate the objects, and lay out
e plans for such a course and to surmount the difficulties in the
ay of its successful operation." The subject thus outlined was
signed to a subcommittee consisting of Charles B. Scott, Oswego
rmal school, Anna B. Comstock, Cornell university, and John D.
ilson, Putnam school, Syracuse. In their report (see p. 486) to
e committee of nine the subject is discussed under the following
eads: What is the purpose of nature study in the schools? What
e the most appropriate subjects? How can we best help teachers
d pupils to do fruitful work? They declare that the first requisite

for success with nature study as an educational instrument is a clear conception of the part it can and ought to take in the training of young children. Accordingly they proceed to point out its functions:

To train pupils in the right use of their senses, so that they will be able to acquire definite and useful knowledge by personal observation.

To train pupils in the use of their intellectual powers, so that they will acquire ability to think about what they observe and to express thought easily and correctly.

To bring children into sympathy with the world of life, to develop their love for beauty and truth and to place them in a reverent attitude toward nature.

To impart definite information on such subjects and by such methods as will arouse interest in other subjects and facilitate school work in the studies called essentials—reading, writing, drawing, composition and geography.

A judicious selection of subjects to be used for these purposes is a matter of much importance. The subcommittee maintains that the study of life has greater educational value than the study of forms, and the dynamic aspects of nature more than morphology. Moreover, life and action are the phases of nature which appeal most strongly to children. For these reasons it recommends the study of life and habits and functions as the most useful and as a preparation for the study of forms and structure, and for the later steps in comparison and classification.

Passing to another phase of the subject the subcommittee suggests that, when teachers engaged in nature study have come to know its purposes, they must feel, more keenly than before, the need of help in the construction of courses by which to accomplish them. To supply such help, it has made a systematic general outline of a course in nature study, which it offers for approval. In this outline subjects are assigned to the several months of the school year according as the season yields appropriate materials for observational study; and the subjects, taken as a whole, constitute a graded course adapted to the successive years from the first to the eighth in the elementary schools. The report mentions the fact that most of the teachers engaged in the schools need, not only help he selection of topics, but instruction in methods of studying of teaching. It therefore recommends that the committee of e and the association pledge their aid in all practicable ways in organization of teachers classes for study of some of the ap- ved topics in the laboratory and the field; that the association leavor to arrange for the publication and distribution of sylla- es on nature study for the direction of teachers classes and the p of teachers in the schools; and that the committee of nine, or association, without delay, take steps to secure cooperation with the various organizations and agencies interested in the promo- n of nature study or responsible for the direction and welfare of elementary schools.

### RECOMMENDATIONS

The conclusions of the committee are summed up in the fol- ving recommendations:

1 **Rank.** That science be taught continuously during the four condary school years, in a graded course parallel with English, tin and mathematics, as a principal subject in secondary edu- tion.

2 **Subjects and time allotment.** That at least one typical anch of earth science, one of biologic science and one of physical ience be taught in all secondary schools, each for one school year th five exercises a week. None of these courses should be omit- d or shortened for the sake of a more prolonged course in another, r for the sake of shorter courses in additional branches.

3 **Methods and tests.** That in science teaching, oral instruction, xtbook study and laboratory or field work go hand in hand, and at all tests for scholarship and promotion be as severe as those plied in mathematics, Latin or English.

4 **Admission to college.** That any physical, biologic or earth ience, which has been pursued consecutively one full year by the pproved class room, textbook and laboratory methods and has tood the approved tests for quality, be accepted by the colleges r admission to their freshman classes.

**5 Details of courses.** That the propositions contained in the several reports of the subcommittees on nature study and secondary science courses be approved and the steps necessary to facilitate their adoption by the schools be taken as speedily as practicable.

**6 Cooperation.** That this association through its committee of nine, or in some other way, endeavor to cooperate with the regents of the University of the State of New York, the department of public instruction, the Associated academic principals, the New York state teachers association and other educational agencies, in efforts to promote the interests of education by making science a satisfactory educational subject in all the schools and colleges.

LeRoy C. Cooley, Vassar college, *chairman*
Albert L. Arey, Rochester free academy
William Hallock, Columbia university
George F. Atkinson, Cornell university
Charles B. Scott, Oswego normal school
Anna B. Comstock, Cornell university
Ralph S. Tarr, Cornell university
Richard E. Dodge, Teachers college, New York
John D. Wilson, Putnam school, Syracuse

## REPORTS OF THE SUBCOMMITTEES

### REPORT ON NATURE STUDY

*To the committee of nine:*

We submit herewith our report and recommendations on nature study.

**Plans of work outlined.** As a result of meetings and correspondence, the plan embodied in the following recommendations has been agreed on. It involves three steps: 1) A statement of the aims of nature study; 2) The selection of topics for study, suited to average school conditions, in the study of which help can be most easily given to teachers; 3) An arrangement by which persons competent to aid the teachers in the introduction of nature study into our schools may be enlisted in the work.

he subcommittee made plans to induce and help teachers to in at once definite work in nature —

**Vork done by members of the subcommittee.** Mrs A. B. nstock has addressed on the subject of nature study seven hers institutes and teachers associations, has given a course of ures on nature study before the training school for kindergarts at Pittsburg and taught the subject at the state summer school Chautauqua.

ohn D. Wilson has personally taught during the year a class nature study in his school, the Putnam school of Syracuse, d directed the work throughout the school. As the Syracuse ining class is in the Putnam school, it is believed that the effect the work done there will be felt eventually throughout the city. e has conducted a class of 50 Syracuse teachers in earth study geography, has given several lessons on nature study in other racuse schools and before the Onondaga educational council and s sent outlines to interested principals and teachers in neighboring wns. Mr Wilson taught nature study in the summer school at ully, Onondaga county, and read a paper on the subject at the eeting of the State council of grammar school principals.

Charles B. Scott has presented the subject of tree study at x teachers institutes, and has addressed the teachers of Binghamn, Utica, Syracuse and Oswego. In six places he has conducted arties of from 50 to 200 teachers for field lessons on our common hade trees and on local geography. In three places he has given tereopticon talks on trees. He taught nature study at the state ummer school at Greenport, Long Island, and at the summer chool of methods at Omaha, Neb. Mr Scott has written about 70 etters, endeavoring to interest science teachers in nature study and nduce them to organize teachers classes and trying to secure the ooperation of all agencies interested in the work.

This statement of what the members of the subcommittee have lone as individuals is made in the hope that it will add weight to heir recommendations.

**Purpose of nature study.** The immediate aim of nature study in lementary schools is quite different from the object of science in igher institutions. While both nature study and science should train pupils to use their eyes and other senses, and thereby gain definite, exact knowledge, and should develop the powers of observation, thought and expression, the teacher of nature study must give attention to the mental interests of boys and girls, and endeavor to quicken their reverence for nature and appreciation of the beauties of the world of sense. Nature should be a means of training our children, not merely to see, think and tell for themselves, but to appreciate what is most worth seeing, thinking about and expressing.

Furthermore, in nature study in the schools, it is necessary to keep in mind the primary purpose of our public schools, as commonly understood, the instruction of children in the so-called " essentials," reading, writing, geography, arithmetic. We must aim to make nature study helpful in these by relating it to other school work; if simply pushed in as an extra, without relation to other work, it will win but a narrow place in the average school.

In all work in nature study teachers should keep in mind these aims: to awaken in pupils a sympathetic interest in the world about them and through that to interest them in other school work; to help them acquire a definite knowledge, through personal observation, of their immediate physical environment, knowledge which can be made a basis for the study of their larger physical environment—in geography—and for other school work; to develop the powers of observation, thought and expression, combining for that end the work in nature study with language and drawing; and, lastly and above all, to cultivate the higher nature of the child, bringing him into sympathy with the world of life, imparting a better appreciation of the beauty in his surroundings, and leading him through nature to nature's God.

Unless these broader, higher aims are kept in mind, nature study will be deficient in results. If the teacher's aim is to furnish children with facts about nature, she may be satisfied to have them read books and do little real studying. If she keep before her as the great aim, their preparation to see and tell, to observe and describe, she can limit her work to mere dissection or analysis and description. If she thinks also of their higher development, she will study the life and beauty of the world of sense, help her children to discover the " whys " and " hows," and make nature study an introduction to the best literature which nature has inspired.

**Recommendations relating to aims.** The subcommittee would c the State science teachers association and all others inter-ed in the introduction of nature study into elementary schools consider the training of children more than the teaching of sub-ts and endeavor so to plan and conduct the work that it will not erely give the children definite knowledge, through personal servation, and develop their powers of observation, reason and pression, but will also bring them into more sympathetic rela-ns with the world of life, lead to a better appreciation and larger joyment of natural beauty, and be an introduction to the literature d art which nature has inspired.

The subcommittee would urgently recommend that the State ience teachers association and all persons interested in this work deavor to impress on teachers the greater educational value of the udy of life, as compared with mere form—of the functional or dyna-ic aspects of nature, as compared with morphology, and commend e study of life, habit and function as the side of nature which ap-eals most to children and which is the best preparation for an nderstanding of form and structure and for the later steps in com-arison and classification.

The subcommittee would recommend that, in all efforts to ad-ance nature study in our elementary schools, pains be taken to how the importance of rendering the study useful in the other work of the school, of selecting topics helpful in geography, of making ature study a basis for a part of the regular work in writing, reading and drawing, and of using the best literature which nature has nspired.

**Topics for study.** The selection of topics must be determined by the aims in mind, the interests and knowledge of teachers and children and the conditions and environments of schools. Appreciation of the higher aims of nature study and understanding of the interests of children will lead to the selection of topics which exhibit the life and work or function of nature (rather than mere form or morphology), which appeal to the sympathies of children and which have the highest content. Consideration of the conditions in our schools will compel the selection of topics in which teachers are interested, about which they know or can readily learn, and for the study of which material can be obtained in most schools.

We believe that the following topics meet these conditions:

*Plant study.* Our common shade and forest trees, such as elms, maples, oaks, poplars, birches, pines and spruces

The development of buds, such as those of horse-chestnut, lilac, elder, pussy willow, beech, maple

The germination of seeds, such as bean, pea, morning glory, corn

The formation and dissemination of seeds, such as mallow, dandelion, thistle, burdock, maple and ash.

Any of the above topics can be studied observationally in almost any school, city or country. Bud and seed study are particularly good for primary grades. Trees are suitable for any grade.

*Animal study.* Our common insects, such as crickets, grasshoppers, caterpillars and butterflies or moths, flies, beetles and bees

Our common birds, such as canary, robin, bluebird, English sparrow, chicken and duck

Our common domestic mammals, such as cat, dog, horse, cow, rabbit.

Insects and birds can be obtained and studied alive even in most city schools. It seems wise to emphasize insect study in early fall, bird study in the spring and the study of common mammals in late fall and in winter.

*Elementary physical geography and physics.* Common minerals and rocks, such as quartz, feldspar, mica, hornblende, calcite, salt, graphite, and such rocks as sandstone, shale, limestone and granite

The work of geographical agents, such as rain, streams and waves, and the results of their work, soil, valleys and hills

The forms of water, including such topics as evaporation and condensation, water-dust, fog, dew, rain, snow and clouds

Heat: its causes and effects, including such topics as combustion and friction; solid, liquid and gaseous states of bodies; expansion and contraction; conduction, radiation and absorption; lamps, stoves and furnaces; temperature, zones and climate; drafts and winds.

The topics suggested above are particularly helpful in earth study or real geography. They can be studied in late fall, in winter and in early spring, when the conditions are not favorable for much plant or animal study.

**Recommendations on topics for study.** The subcommittee on nature study would therefore recommend:

That the committee of nine and the New York state science achers association propose the following topics for study in our hools and endeavor to help teachers in working along these lines.

*For years or grades one to four*

September, October, November
  1 Formation, protection and dissemination of seeds
  2 Our common insects. Life, habits, life history, general structure

November, December
  Our common domestic mammals, cat, dog, rabbit, horse, cow

January, February, March
  Forms of water. Evaporation, condensation, water-dust, mist, fog, dew, rain, snow, etc.

March, April, May, June
  1 Development of buds and germination of seeds
  2 Common birds. Canary, chicken, robin, bluebird
  3 Some insect study. Development of cocoons, galls, etc.

*For years or grades five to eight*

September, October, November
  1 Insects. Habits, life history, structure and classification, relation of insects to man
  2 Some observation of trees. Preparation for winter, formation of fruit, coloring and falling of leaves, and formation and protection of buds

December, January, February
  1 Common minerals and rocks
  2 Heat, causes and effects. Changing solids to liquids and liquids to gases, expansion and contraction, combustion, relation to winds, currents, zones and other geographical phenomena

March, April, May, June
  1 Our common shade and forest trees
  2 Our common birds, life, habits, adaptation, structure, classification, relation to man
  3 Work of geographical agents. Rain, streams, waves, soil-making, formation of valleys

John D. Wilson suggests that "work in nature study, as we are considering it, need not be continued beyond the sixth year; and after that should be superseded by the earth sciences, beginning with geography." With this exception the members of the subcommittee are in entire accord in their recommendations.

**Plan of work with teachers.** The education of most teachers in our public schools has been gained from books and they depend on books, to a large extent, in teaching. Nature study, specially, will show teachers the value of individual observation as a foundation for thought and expression. Most teachers need help in the observation of nature before they can train their pupils to observe. This can be obtained by means of teachers classes, organized for laboratory work, not merely for talks on nature study. These classes can best be conducted by teachers in elementary schools who have gained some knowledge by observation and are familiar with the conditions and needs of such schools or by science teachers in high schools, normal schools or colleges. In general the work can be done best by school principals or by high school science teachers, whose work brings them in contact with teachers and schools. These teachers laboratory classes should be supplemented by field lessons for the study, in natural relations, of seed dissemination, trees, insects and birds. Stereopticon talks to teachers will be helpful. The most advantageous work for teachers is done at summer schools. The conditions there are most favorable for out-of-door work and the collection of material. For the help of persons conducting these classes and for teachers deprived of such instruction, syllabuses should be printed, indicating in some detail topics and methods. These, prepared by competent persons, could often be published in the educational papers and afterwords issued in leaflet form, at slight expense. At slight cost excellent illustrations for the aid of teachers in the study of trees and birds can be provided. The cause of nature study will be advanced by the cooperation of all agencies interested in the promotion of science and nature study and in the training of teachers. The subcommittee would therefore add to its recommendations the following:

**Recommendations for helping teachers.** That the committee of nine and the State science teachers association advise and assist the organization of teachers classes for observational study, supple-

ed by stereopticon talks, of some of the topics already recom-
ded.

at the committee of nine and the State science teachers associa-
express by resolution their recognition of the value of summer
ols, state and private, in interesting and helping teachers in
ine nature study, and that they pledge their efforts to have
ematic work in nature study, along the lines this committee has
ated, carried on in the summer schools.

hat the committee of nine and the State science teachers asso-
on endeavor to arrange for the publication of syllabuses and out-
s on nature study for the direction of teachers classes and in-
dual teachers, and for the furnishing of such publications and of
strations to the teachers of the state at a minimum cost.

That the committee of nine and the State science teachers associa-
n endeavor to cooperate in the furtherance of nature study in
mentary schools with the department of public instruction, the
te normal schools, teachers training classes, summer schools and
chers institutes, the bureau of nature study of the College of
riculture, the State teachers association, and with the educational
pers of the state.

### RÉSUMÉ OF RECOMMENDATIONS OF SUBCOMMITTEE

1 Recommendations relating to aims in nature study
  - *a* Recognition of higher aims
  - *b* Recognition of greater value of study of life and function
  - *c* Correlating nature study with school work

2 Recommendations relating to topics for study
  - *d* Topics for study

3 Recommendations relating to means of helping teachers
  - *e* Teachers classes
  - *f* Summer schools
  - *g* Syllabuses and illustrative material
  - *h* Cooperation with other agencies

Respectfully submitted

CHARLES B. SCOTT
JOHN D. WILSON
ANNA B. COMSTOCK
*Subcommittee on nature study*

## REPORT ON EARTH SCIENCES

### PHYSICAL GEOGRAPHY

**Place in course.** The committee of 10 has proposed to place physical geography in the first year of every course in the high school; and the subcommittee on physical geography in its report to the National educational association, a committee consisting of representatives from the New England association, the Middle states association, the North central association, the Southern association, the National educational association, (natural science section) and the American association for the advancement of science, has made nearly the same recommendation, though in this case it is suggested that the subject come either in the first or second year[1]. The reasons for making this recommendation are fully stated in these reports and need not be repeated here. It is the opinion of the numerous teachers to whom the question was submitted that physical geography should come as early as possible and should occupy at least three periods a week for a year, one period to be devoted to laboratory work. With this your subcommittee agrees.

**Subject-matter.** Two of the three hours may be devoted to class room work, in which the general subjects of air, ocean and land are studied. Some may prefer this order—land, ocean, air, which will serve exactly as well; the order seems immaterial. Questions of pure physics, descriptive geography and biology should be avoided whenever possible, and geographic distribution should be taken up only when it seems to have a distinct relation to physiographic causes. Some simple physical, and still more some geologic principles will be necessary; but such of these as are not treated in the textbook are so simple that they can be readily introduced by any competent science teacher.

From the outset the relationship of physiographic phenomena to life, particularly to man, should be pointed out, specially where this can be brought within the experiences of the pupils, as it can be by making use of the home environment for illustration. Another prominent feature of the work should be the recognition of the causal notion—the relation between cause and effect.

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[1] This report by the chairman, Prof. Brigham, is printed in the *Journal of school geography* 1898, 2:248-62.

following brief syllabus is proposed as a rational outline for a school course in physical geography for the first or second

*Principal divisions of the subject*

earth as a planet
air (the atmosphere)
ocean (the hydrosphere)
land (the lithosphere)

he earth as a planet (including some mathematical geography)
- *a* Size
- *b* Shape. Proof of its rotundity
- *c* Surface features and internal condition
- *d* Rotation; how proved. Latitude and longitude
- *e* Revolution; how proved
- *f* As a member of the solar system. The nebular hypothesis

The air (meteorology)
- *a* Composition; how shown
- *b* Temperature; how recorded. The thermometer and thermograph. Isothermal charts. Isotherms. The heat equator. Diurnal and seasonal range. Weather maps
- *c* Pressure, hight and weight; how determined. The barometer and barograph. Isobars. Weather maps
- *d* Winds. Causes. Characteristics. Planetary, terrestrial, irregular. Weather maps
- *e* Storms. Cyclones. Anticyclones. Hurricanes, local storms. Study on weather map
- *f* Rainfall; how determined. The rain gage. Humidity, absolute and relative. The dew point. Clouds. Forms of water. Rain, mist, snow, hail, etc. Distribution of rainfall. Causes. Relation to man
- *g* Climate and weather. Weather maps. Their use and construction
- *h* Distribution of plants and animals with reference to climatic causes

The ocean (oceanography)
- *a* Extent, volume and divisions
- *b* Composition; how shown

*c* Depth, topography and bottom conditions; how determined

*d* Temperature at surface and at different depths

*e* Density

*f* Movements. Waves; cause, form and effects. Tides; cause, changes on coast; and effects. Currents; characteristic, cause, influence on ocean and air temperature. Influence on man

4 The land (physiography)

General considerations

*a* Its extent in comparison with the ocean

*b* Its mineral and rock constituents. A few of the more common minerals. A few of the more common rocks

*c* Rock classification. Stratified, igneous, metamorphic

*d* Rock characteristics. Strata, joints, folds, anticlines, synclines, faults, dip and strike

*e* The crust of the earth. Thickness. Internal temperature. Its age

Agencies that have modified its surface

*a* Atmospheric erosion. Weathering, etc. Transportation. Deposition

*b* Rivers and river valleys, lakes, waterfalls. Alluvial cover, talus, alluvial plains and deltas. Cycle of river development

*c* Glaciers. Glacial phenomena. Evidences of past glaciation and past glacial periods

*d* Standing water. Oceans, lakes and their work and importance

*e* Elevation and subsidence. Influence on the coast

*f* Volcanos and volcanic phenomena. Earthquakes. Hot springs and geysers

Forms of the land and their origin

*a* Continents

*b* Islands, oceanic and continental. Origin and history. Illustrative examples

*c* Plains. Origin and life history. Kinds. Instances

*d* Plateaus. Dissected, mature, etc. Illustrative examples

*e* Mountains. Young, old, etc. Examples
*f* Sea shores and shore lines. Effect of elevation; of depression. Changes in form

**aboratory and field work.** At least one period a week should devoted to this work. It is difficult to make, in brief form, any equate suggestions on this topic, for so much depends on the iipment of the school and on its environment. The teacher ould make use of all the material at hand and provide some laborary work on each of the large divisions of the subject, though turally most stress should be placed on the air and the land. A oratory notebook should be carefully kept. The teacher is rerred to some of the more available literature for information touchg the equipment and use of a laboratory in physical geography. 1 the state of New York, through the aid of the regents, it is much iore easy to obtain a laboratory equipment than in most states. he following papers deal with the topic under consideration.

**General papers.** Cornish, "Laboratory work in elementary physography," *Journal of school geography*, 1897, 1:172-79, 204-9; Davis, The equipment of a geographical laboratory," *Journal of school eography*, 1898, 2:170-81; Tarr, "Laboratory methods of instrucion in geology and physical geography," *Regents bulletin* no. 32, 895, p. 992-1011; Tarr, "Teachers' outfit in physical geography," *School review*, 1896, 4:161-72, 193-201; "Report of the committee n geography" in the *Report of the committee of* 10, U. S. bureau of ducation, Washington, 1893.

**Meteorology.** Jameson, "Some suggestions for teaching elementary meteorology," *Journal of school geography*, 1898, 2:2-9, 56-62, 96-104, 139-46; Ward, "Meteorological observations in schools," *Journal of school geography*, 1897, 1:41-48; *Maps*: Davis, King and Collie, *Report on governmental maps for use in schools*, Henry Holt & Co., 1894; Davis, "Large scale maps as geographical illustrations," *Journal of geology*, 1896, 4:484-513; Davis, "The selection of topographical maps for schools," *Journal of school geography*, 1898, 2:340-45; Davis, "Topographic maps of the United States," *Journal of school geography*, 1897, 1:200-4; Davis, "State map of New York as an aid to the study of geography," *Regents examination bulletin* no.

11, 1896; *Topographic atlas of the United States, Physiographic types*, by Henry Gannett, U. S. geological survey, Washington, 1898.

**Models.** The greater number of models available are those prepared by E. E. Howell, 612 17 st., N. W., Washington, D. C. Three excellent models (Harvard geographic models) are published by Ginn & Co., Boston. Other models may be expected to appear from time to time.

**Field work.** Tarr, *Suggestions for laboratory and field work in high school geology*, The Macmillan Co., 1897; Tarr, " Field work in geology and physical geography," *School review*, 1897, 5:519-29.

**Books and lantern slides.** There should be a library in the school in which books on physical geography have a place. The students should be taught to use these works of reference by being referred to them occasionally and held responsible for study of them. In some of the articles of which mention has been made lists of desirable books will be found. Such books are also mentioned at the close of the chapters in Tarr's *Elementary physical geography*; but the most complete list of books of reference, an exceedingly valuable volume for this reason, is Mill's *Hints to teachers and students on the choice of geographical books for reference and reading*, Longmans, Green & Co., 1897. Articles by Tarr on the physical geography of New York have appeared in the *Bulletin* of the American geographical society, vol. 28, 29 and 30, and the series will be completed in vol. 31. Wherever possible lantern slides should be used to illustrate the features which the pupils can not themselves see. A list of a certain number of geographic lantern slides can be obtained from E. E. Howell, Washington. In the Bickmore series of slides, which are sent to so many schools in New York, there are excellent illustrations of physiographic subjects, and most teachers of physical geography who make the effort can obtain these.

**College recognition.** Because of the breadth of the field comprehended, embracing in an elementary way the first principles of several sciences, physical geography should not be placed among the list of *sciences* for college entrance, that is to say, it can not be placed in the same category with a single science, such as physics, botany, or meteorology. However, when taught as above suggested,

college might properly recognize it among elementary entrance
jects, with a rank equal to that of algebra or history. If it be
e, every student entering college will be obliged to have at least
measure of science training. Such a requirement will also tend
insure a certain amount of elementary science work to the multi-
le of pupils who do not go to college and who might otherwise
no science training or information.

### GEOLOGY

Besides requiring physical geography for all courses in either the
t or second year in the high school, provision should be made for
of the constituent parts of physical geography, in either the
rd or fourth year of the course, after physics and chemistry have
n studied. This work, whether required or elective should ex-
d throughout the year.

Three subjects, meteorology, physiography and geology, at the
sent time have a certain claim to a position in the high school
riculum, at least as electives. Though Harvard has placed the
t two in its list of entrance subjects, it is your committee's opin-
that, at least so far as New York is concerned, meteorology and
siography have less claim to a place in the curriculum than geol-
. The principal reason for this conclusion is that there are prac-
lly no teachers for the subjects and few are appearing. More-
r, in most colleges these subjects have not yet won a place, and
sequently examinations could not be set in them. However,
report is not intended to discourage teachers who are ready and
ling to teach either of these subjects. With geology the case is
erent. There are already a large number of good teachers in
subject in New York, and from year to year their number in-
ases. Besides, geology is recognized in practically all the col-
es and universities of the state, and at some of them has already
nd a place among the possible entrance subjects.

Since all important educational conferences have agreed as to the
per place for physical geography in the course, and the general
ure of the work, it has seemed well to propose an outline for a
h school course in physical geography. But with geology there
o such consensus of opinion; and, chiefly for this reason, your

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committee prefers to make this a preliminary report on geology and for the present not to offer a definite outline.

We make the following recommendations:

That geology receive a place in the third or fourth year of the high school course, as a required study or, perhaps better, as an elective.

That it occupy one full year, preferably for five periods a week.

That much less relative attention be given the stratigraphic and paleontologic sides than in the present regents syllabus, and that the chief stress be placed on the structural and dynamic sides. This is not intended to apply to laboratory and field work, but solely to textbook work. The reason for making the recommendation is that the prevailing custom of memorizing unconnected facts and mere catalogues of names is vicious.

That one, or better two, of the periods be devoted to laboratory and field work (*See* Tarr, *Suggestions for laboratory and field work in high school geology,* Macmillan, 1897).

That in addition to ordinary textbook work extensive use be made of more advanced textbooks and works of reference.

That the colleges and universities of the state be requested to place this subject, when taught as above recommended, in the list of science subjects, one of which may be offered for entrance. To indicate what is meant by the last recommendation we refer to the recent action of the Cornell faculty, which has voted to permit students to offer at entrance one of the following sciences: physics, chemistry, botany, zoology or geology; when taught in the way indicated, for five periods a week, this science entrance subject being received in lieu of one of the advanced subjects hitherto recognized.

R. S. Tarr
R. E. Dodge
R. H. Cornish
J. M. Jameson
} *Subcommittee on earth sciences*

### REPORT ON BOTANY

The following syllabus presents an outline for a year's work in elementary botany. Some schools are already prepared to give to classes a full year's work in this subject, and it is hoped that others may do so, with good results both in method and practice. A year's rk affords a more satisfactory unit for counts than a shorter time hen the student desires to offer botany as one of the subjects for trance to a college or university. Where it is at present impos- ble to continue the work a year, the course may be abbreviated by udying the central topics under each subject. For this purpose e most important topics, or those which present the less difficulty e printed in the larger type. By thus studying central topics from l the subjects harmony and proportion in the relation and sequence f the subject-matter of the entire course will be preserved, while the ethods of observation, induction and the arrangement of facts in gical sequence will still be inculcated. The outline is so flexible hat, while the general plan can be quite rigidly adhered to, the mount of work can be varied to meet necessities, the full year's ork being still regarded as the desired course. This flexibility will dmit a quite careful and in many cases briefer study of the topics, r portions in fine print as collateral or supplementary work.

Where it is possible, the teacher should give talks or lectures on the subject in advance of the practical work, and at the beginning of each practical exercise a short talk on the special work for the period, giving general directions for manipulation of the material, and emphasizing the things to be studied. During the progress of the practical work specific directions and assistance can be given, but the student should be encouraged to acquire more and more independence in his pursuit of the subject. Each student should make neat drawings and notes of the objects studied or the experiments performed, and arrange them in a notebook for examination.

### Outline for practical work in elementary botany

*Note.* In short courses, when only one or two microscopes are at hand, too few to enable the pupils to use them, it will be necessary for the teacher to make demonstrations. In such cases or when pupils have not pursued nature studies it may be desirable, for the first few exercises, to take up some of the subjects suggested in paragraph 4. (*See also* paragraphs 77, 79.) This will afford easy studies on seeds and seedlings. Several kinds of seeds may be used, their germination carefully followed, the parts of the seedling described, etc. This can be made preliminary to a study of protoplasm, since in the studies of protoplasm the root hairs of seedlings are employed for the purpose of showing later how the protoplasm aids the plant in taking up nutrient solutions.

Following (*see* paragraph 81) this study of seedlings several exercises can be devoted to studies of buds, twigs, etc., with excursions for the purpose of oecologic observations of trees and shrubs during the winter or autumn, in whichever of these seasons the work begins. These exercises can be followed by a study of protoplasm in the root hairs of the seedling, and then in the threads of spirogyra as indicated in paragraph 1. The other paragraphs can then be taken up in the order indicated in the outline. But from time to time, as the work progresses, excursions should be made for the purpose of some oecologic observations specially related to the work in hand. Specially is this the case when the study of the flowering plants begins in the spring. As several of the families are studied, excursions can be made for the purpose of observing these plants in their natural habitat, and for studies on pollenation etc. Topics for such studies are indicated under the 3d division of the outline, oecology

## Studies of life processes in plants

### PROTOPLASM

Protoplasm in a simple alga: spirogyra. The alga spirogyra is found in pools of quiet water, in ditches or in slowly running water of streams. It forms green mats of tangled threads.

1 **Structure of vegetative stage of spirogyra thread.** Mount a few threads of spirogyra in a drop of water on a glass slip, and cover with a cover glass for examination with the microscope. Study the thread; note size, shape, and form of the individual cells; the chlorophyl band; groups of starch grains containing a small round central body, the *pyrenoid*. In each cell note the nucleus near the center; radiating strands of protoplasm, and wall layer of protoplasm.

*Tests for protoplasm.* Study the reaction of fresh material in each case in treatment with the following reagents, examining under the microscope: iodine (a solution of potassium iodid of iodine), 1% aqueous solution of eosin, alcohol, alcohol followed by a 1% aqueous solution of eosin, glycerine.

**Protoplasm in a fungus: mucor.** This is a mold which grows on old l, or horse dung, decaying vegetables, etc., in damp situations. Mount of the white threads in water for microscopic examination. Study , branching, structure, and compare with spirogyra. Test for pro-sm as in spirogyra. Note movement of protoplasm. (The best re-can be obtained with material grown in dishes in a nutrient substance gelatine or agar containing peptone broth. In lieu of this, glass slips be placed by the side of growing threads in a moist chamber to bait : of the threads on them).

tudy in a similar way protoplasm in the alga nitella; in the cells of the inal hairs on flowers of the spiderwort (tradescantia).

**Protoplasm in the root hairs** of corn or some other seedling rminate several different kinds of seeds in the folds of damp cloth aper, to keep the hairs free from soil); in the cells of the tissues one of the higher plants, as portions of the petioles of leaves, r growing points, or near the joints of stalks of growing Indian n. The latter is specially good. For the study of protoplasm in ues, thin sections of the parts must be made with a razor or er sharp instrument.

Compare results and describe protoplasm.

### OSMOSE, ABSORPTION, ETC.

**Osmose in a simple alga: spirogyra.** Mount a few threads water and draw under the cover glass a 5% solution of salt, and ickly watch the effect on the protoplasm with the aid of the mi-oscope. The protoplasm moves away from the cell wall. Now aw under fresh water to remove the salt solution and watch the sult. The protoplasm moves out again against the cell wall.

5 Study osmose in a similar way in a fungus (thread of mucor or of the ter mold, saprolegnia); in the cells of the tissues of the higher plants; root hairs of seedlings; in the red colored cells of the beet.

7 Place thin slices of a beet or carrot in a 5% salt solution for out 30 minutes (or an hour); note the result when an attempt made to bend them. Now place the same slices in fresh water r the same period of time and note the result when an attempt made to bend them. How are these results interpreted? The lt solution withdraws some of the water from the cell sap of all e cells of the beet slice. Each cell loses its turgidity, conse-uently the mass of cells loses its turgidity. When the salt solution removed and water added turgidity is again restored because the

cell sap absorbs water thus restoring the turgidity of the individual cells.

8 In a similar way treat succulent leaves or fresh leaves. Do not immerse the cut end of the petiole.

9 Set up an experiment to observe diffusion through an animal membrane which separates water and a sugar solution. Fit an animal membrane like a piece of bladder over the large end of a thistle tube. Fill the bulb of the tube and a small portion of the tube with a 15% solution of sugar. Immerse this end of the tube in a vessel of water so that the two liquids will be at the same level at the start. In a short time the liquid rises in the tube. The sugar solution gains more water than it loses, because the water has no solvent in it.

### WATER CULTURES

10 Germinate seeds of corn, peas, beans, etc. in folds of a damp cloth or paper. Set the young seedlings in crockery culture jars; no. 1 containing a "nutrient solution" with iron; no. 2 nutrient solution with no iron; no. 3 distilled water; no. 4 seeds of plants in soil in pots at the same time that the other seeds were started to germinate. Keep all under the same conditions of temperature, etc. From time to time for several weeks compare the numbers.

### HOW PLANTS ABSORB NUTRIENT SOLUTIONS

11 Study young seedlings germinated in the folds of a damp cloth or paper to note the delicate root hairs clothing a portion of the root. Make thin sections of this portion of the root to see the relation of the root hairs to the cells of the root.

12 Attempt to wash off the soil from the root hairs of seedlings grown in soil. Examine with the microscope root hairs that have been washed. Particles of soil are so firmly glued to the root hairs that the protoplasm can absorb water from the film of water surrounding the particles.

13 With seedlings grown in damp paper or cloth test the root hairs for an acid by touching the root hairs to blue litmus paper. The blue paper should change to red showing presence of an acid substance. This acid aids in dissolving certain of the mineral substances in the soil so that the plants can take them up for food.

other acid, carbonic acid, which is not the chief one in reddening litmus paper, is the principal one which dissolves these mineral stances.

### TURGESCENCE

14 Cut off a leafy succulent shoot and allow it partly to wilt. t off the end fresh again and place the cut end in a vessel of water revive. This may be hastened by placing a bell jar over the nt.

5 Fasten the cut end of a similar wilted shoot in one end of a U tube that the end of the tube will be air tight. Fill this arm of the tube with er and the other arm with mercury, and fasten in an upright posi- . The pressure of the mercury on the water hastens the restoration of gidity.

### TISSUE TENSIONS

16 Take a long section of the petiole of a rhubarb plant, or of aladium or celery petiole. Shave off the outer portion in strips. te the result by attempting to replace the strips. The outer ips will be the shorter. From short sections of a willow shoot el the bark in one piece. Attempt to replace it. It is now orter than the circumference of the shoot. In the first place re is longitudinal tension, the outer tissues tending to shorten d the inner tissues tending to lengthen. In the second place the sion is transverse.

### ROOT PRESSURE

17 Cut off the stem of a vigorously growing plant, a potted lsam or begonia for example. With a short section of rubber ing connect an upright glass tube 2/3 meters long with the mp of the plant still attached to the roots in the soil. Note the ult from time to time for several days. Pressure from root ab- ption causes the water to rise in the tube.

### TRANSPIRATION

18 Place some freshly cut leaves and leafy shoots where there is noderately dry air; place others under a bell jar. Discover the use of the wilting. Cover a potted plant, the soil and pot of ich have been sealed by wrapping with rubber cloth, with a bell , and after several hours note the result. The leafy shoots and

the plant lose water in the form of water vapor, which forms by condensation a moisture film, or drops of water later on the inside of the bell jar.

19 Place two potted plants on a scale one on each arm. Cover the pot and soil with a rubber cloth. Cover one of the plants with a bell jar and with weights balance the other arm. After a few hours note the result.

### STRUCTURE OF A LEAF

20 Make thin sections of a leaf of ivy, begonia, or other plant and mount in water. Note the epidermal layers; palisade cells; loose parenchyma; intercellular spaces; stomata.

21 Tear a leaf in such a way as to strip off some of the thin epidermis from one side, and mount this in water. Study the form of the epidermal and guard cells of the stomata.

22 Cut off a young calla leaf with a long petiole. Immerse the blade of the leaf in water and blow through the petiole. There is a communication of air through the petiole and leaf in the intercellular spaces and frequently " bubbles of air " will come from the stomata while one is blowing through the petiole.

### MOVEMENT OF LIQUIDS IN PLANTS

23 Place the cut ends of leafy shoots of the balsam, geranium, corn plant, celery or caladium petiole in a solution of a red dye (fuchsin is excellent). In a few hours note the result. Cut the stem across and note the colored areas. Split some of the stems.

### STRUCTURE OF THE VASCULAR BUNDLES

24 Make thin cross and longitudinal sections of some of these stems or of others, with a razor, and study the structure of the areas where the colored liquid rises. Compare in the different stems. Break off an old dead corn stalk. Pull out the fibrovascular bundles in long strands.

### EXCHANGE OF GASES IN PLANTS

25 Place some green alga like spirogyra or vaucheria in spring or brook water, and set in the sunlight. Set a similar preparation in the dark. Compare results. Bubbles of gas rise from the former, not from the latter. Prepare the same experiment using some of the higher water plants like elodea. In both cases oxygen is given off.

Try the same experiment in water that has been boiled and cooled t agitation; then in water in which oxygen has been introduced by ion; again after oxygen and carbon dioxid have been introduced. can be introduced by blowing into the water through a glass tube, arbon dioxid coming from the "breath." An abundance must be uced.

### STARCH FORMED BY GREEN PLANTS

Iodine colors starch dark blue or blackish. Kill some threads rogyra which have been standing in water in the sunlight for time with alcohol; stain with potassium iodid of iodine to t the presence of starch.

Test for starch in the green leaves of plants which have been time in the sunlight. Carefully decolorize the leaves first by g in alcohol, then place in the iodine solution. Or use per's solution (50cc water to 80 grams chloral hydrate), adding s a little of an alcoholic tincture of iodine. Place the green of the plants directly in this solution for an hour or two.

Test algae or leaves which have been in the dark some time. arch or but little is found. Light therefore is necessary.

n the afternoon cover a portion of a green leaf by pinning cork on ides in such a way as to exclude the direct sunlight. On the after- of the following day, if the day is bright, test the entire leaf for starch. the uncovered portion shows the reaction. The starch formed the us day in the leaf was removed during the night and carried to other of the plant. Test potatoes for starch.

Chlorophyl bodies. Study the form of the chlorophyl bodies colored) of several plants like spirogyra, leaf of a moss, and tion of leaf of a higher plant.

there is time test in other algae, fern prothallia etc. Remove the color with alcohol; the body of the chloroplast remains. Test the phyl bodies in leaves of mosses, fern prothallia, etc. for starch. The is first formed in the chlorophyl body in the presence of sunlight.

### RESPIRATION

In the bottom of a tall glass cylinder tightly closed place two ee handfuls of peas. Cover with water for 12 to 24 hours ey have become thoroughly soaked. Pour off all the water t a small quantity in the bottom and set the vessel in a warm Seal the cover to the mouth of the vessel with vaseline. 4 hours lower into the vessel a lighted taper. It is extinguished because the peas have consumed some of the oxygen during germination. Lower into the cylinder a small vessel containing fresh lime water. A whitish film and a whitish precipitate are formed. Blow with the breath on some lime water in another vessel. The same film and precipitate appear. This precipitate is calcium carbonate formed by the union of $CO_2$ with the calcium in the lime water. Therefore the peas in germinating gave off $CO_2$, and the process is the same as respiration in animals. Baryta water may be used instead of lime water.

34 If a number of opening flower buds are at hand, or a number of growing mushrooms, place them in the bottom of a similar vessel, closing tightly, and make the same tests. Compare the growth of germinated seedlings, some in ordinary air, some in an atmosphere with $CO_2$ where O is absent. An atmosphere of $CO_2$ may be obtained by germinating peas as described above. The same vessel may be used after the former experiment is concluded. Place some wet filter paper on the peas, and place the germinated ones on this. Fit up another vessel with a small quantity of water in the bottom, and suspend in this germinated peas like those in the first vessel. They can be suspended on a wire pan covered with wet paper. Cover this vessel as the former, and after 24 hours note the result. Oxygen is necessary for growth.

*Note.* Respiration should not be confused with transpiration. In transpiration the plant loses water while additional water is supplied by root absorption. In respiration oxygen enters the protoplasm of the plant by osmosis, and oxidation takes place forming $CO_2$, which then passes off. Respiration should not be confused with the absorption of $CO_2$ and the giving off of O, which takes place in $CO_2$ assimilation.

### ORGANS FOR ABSORPTION OF LIQUID NUTRIMENT

35 Study root hairs of seedlings; the rhizoids of mosses; liverworts. How do the algae absorb nutriment? How does mucor? Through the surfaces of the plant body bathed with the nutrient substance. Examine the mycelium (spawn) of mushrooms.

36 Make sections of a carnation leaf through a "rust" spot; treat in a strong solution of chloral hydrate for several minutes, wash, and stain with eosin; trace the mycelium between the cells of the carnation leaf, and the haustoria within the cells. Study the absorbing organs of the dodder (cuscuta).

### GROWTH

37 **Region of elongation.** Take seedlings of corn, pea, bean, pumpkin, or of other plants which have been germinated in folds of damp cloth or paper. With a fine pointed pen and india ink

t off 10 mm of the end of the root of several of the seedlings, ng the first mark one millimeter from the tip, and the others llimeter apart. Keep the seedlings in a moist chamber where oots will not get dry, but there must be no water in contact with nk. In 24 hours observe where the growth in elongation takes e.

n the stems of beans growing in pots mark off distances 5mm t on the very youngest nodes. Note the growth to see where elongation takes place.

8 **Direction of growth.** Place several of the seedlings which e been growing in a normal position in a horizontal position, ., so that the root and stem will lie horizontally, and with the s so that they will be free to grow in any direction. Keep in ioist chamber. In 24 hours note the direction of growth of root l stem.

9 Grow seedlings in pots with a one sided illumination. Grow ne pots in the dark and some in the light for comparison.

### IRRITABILITY

0 Note the day and night position of leaves of various plants. ver an oxalis, bean plant, sunflower, or other rapidly growing nt, so that it will be in the dark for a day or two. Uncover it ring the day and see the result.

1 Grow in pots, plants of mimosa (sensitive plants) several months in ad-
ice of the time when they are to be used.

Pinch one of the terminal leaflets of the mimosa plant, and watch the effect.
· the plant.

The effect of different temperatures on seeds, their germination, on growth
. may be tested.

## **Studies of representative plants**

### GREEN ALGAE

### *Conjugatae*

42 **Spirogyra.** For form and structure of the vegetative threads spirogyra see studies of protoplasm.

Material of spirogyra in conjugation can be collected during the tumn or spring. If not to be used then, it can be preserved in 5% formalin.

43 Mount a few threads of a tuft which contains fruit in water for microscopic examination. Study the conjugation threads, connecting tubes, the zygospores, the passage of the protoplasm from one cell through the tube to another.

44 If desired several different species may be studied. Also species of zygnema, mougeotia, and the desmids..

### *Confervoideae*

45 **Vaucheria** (green felt). *V. sessilis.* Select material in fruiting condition, fresh or preserved in formalin. Mount for microscopic examination. Study form of thread, branching, contents; the sexual organs, oogonia with egg in each (oogonium is short branch enlarged and more or less rounded), fertilized egg in oogonium with thick brown wall, called also oospore; antheridia, curved or coiled branches, one or more near oogonium curved, and note frequently several oogonia in groups.

46 **Oedogonium.** Use material fresh or preserved in formalin. Threads unbranched composed of cylindrical cells. Note here and there several cross walls close together appearing like small pans piled one within another, showing vegetative division of oedogonium. Observe oogonia—here and there enlarged cells, some containing fertilized egg with thick brown wall (oospore). Also antheridia—either on the same thread or on different threads, as in some species. Cells short, perhaps more broad than long. In some species dwarf males, short, club-shaped, appear on the oogonia.

47 **Coleochaete.** This is usually quite difficult to obtain, but may be procured from the Ithaca botanical supply co, Ithaca, N. Y. Compare the circular coleochaete (C. scutata) with spirogyra, vaucheria, oedogonium. Other confervoid algas may be studied if desired, as cladophora, drapernaudia, chaetophora, etc.

### PHAEOPHYCEAE (brown algae)

48 **Fucus** as an example. *F. vesiculosus.* Employ fresh material from the seashore, or material preserved in formalin or 70% alcohol. Study the form of the plant, noting vesicles; also the numerous conceptacles, usually situated in the flattened lenticular end of the branches.

Prepare sections of the fruiting ends to study the form of the conceptacles, the oogonia, eggs and antheridia within. Sometimes both antheridia and oogonia are in the same conceptacle, sometimes in different ones.

### RHODOPHYCEAE (red algae)

49 **Gracilaria or rhabdonia.** Have material fresh from the seashore or preserved as in fucus. Study form of the plant, the projecting cystocarps. Section some of the cystocarps to study the structure and the form of the

ospores. Study the tetraspores in the wall of other specimens which not contain cystocarps. Species of red algae with naked cystocarps like mium, callithamnion, etc., may be studied if desired.

## FUNGI

50 **Mucor.** Select a specimen of the black mold (mucor) grow- g on bread kept in a moist chamber. The plant also occurs on aying vegetables. Study the white branching mycelium (see dy of protoplasm under caption mucor). Mount some of the terial with the stalks bearing the black heads (sporangia). Study e stalks, and their origin in the mycelium, the sporangia or spore ses, the gonidia, in large numbers in the sporangium, or in many ses falling away.

51 If material can be found forming zygospores, study this process. Study e gemmae, little buds on the mycelium of some species, or the chains of lls in others.

52 **The water mold** (*saprolegnia*). Collect algae with pool water from veral different places. Keep in vessels and throw in each several dead es. In the course of a week or 10 days examine for a fungus. Quite obably it is the water mold, saprolegnia. Study the mycelium; the long orangia; the motile gonidia escaping from the end of some.

In some of the older material oogonia on short branches containing veral eggs can often be found. Near them may be found in most species theridia. Compare with vaucheria.

53 Relatives of the water mold are found in the downy mildew of the grape nd other plants (peronospora); and in the white rust (cystopus), of the hepherd's purse.

54 **Rusts; wheat rust** (*puccinia graminis*). Select wheat or oats ffected with the red and black rust. Preserve dry or in formalin r 70% alcohol. Study form and color of the rust spots. Tease out n water for microscopic examination material from both kinds of pots. Study the uredospores (one celled) and teleutospores (two celled). Collect in early summer some of the leaves of the barberry affected with the cluster cup fungus. Preserve some dry and some in formalin. Study the cluster cups (aecidia), the aecidiospores; the spermagonia on the opposite side of the leaves in the affected spots. The teacher can make sections to show the structure of the cups.

55 **Sac fungi** (*ascomycetes*). Examples may be taken from the common powdery mildews. These plants form surface mildews giving a whitish appearance to the leaves, stems or fruit.

56 **Willow mildew.** Preserve dry. Mount in water. Study the mycelium, and gonidia (borne in chains) in material which shows an abundance of the whitish mildew. Taking leaves which show numerous minute, black specks (fruit bodies) study the fruit bodies or perithecia (perithecium). Mount some in water. Observe first with low power of microscope for outward form, etc. Then crush some by pressure on the cover glass, and study the contents, asci (ascus), and ascospores, with the aid of the high power.

57 **Mushrooms** (*basidiomycetes*). In the winter these may sometimes be found in conservatories or in mushroom cellars. At other seasons they are abundant in the woods and fields. Study the form of the plant, cap (pileus), gills, stem, ring or veil when present, volva when present, the mycelium in the wood or soil. Section one of the gills, mount in water and study the structure of the gill (trama, subhymenium, basidial layer, sterigmata, and basidiospores). Puffballs may be studied if there is time.

## Bryophyta

### LIVERWORTS (Hepaticae)

### *Thalloid liverworts*

58 **Riccia.** This forms green circular patches, or ribbon like sheets which fork frequently, and grows on muddy soil or floats on the water. Study the form of one or more species obtainable, noting on the under surface the organs for absorption of nutriment. If material is in fruit, section the thallus for the study of the structure of the capsule and the spores.

59 **Marchantia polymorpha.** Collect in damp places along shaded streams or in swamps, or wet ground. Preserve in 2.5% formalin or in 70% alcohol.

Observe the form of the plant, cupules with buds or gemmae; rhizoids. Distinguish the male plants, with stalked circular discs crenate on the margin, the antheridiophores or male receptacles. Section to study the antheridia (one in each flask-shaped cavity); the sperm cells. If material is fresh the spermatozoids are frequently seen. Distinguish the female plants, with larger, umbrella-like female receptacles, the archegoniophores.

Make longitudinal section to study the flask-shaped archegonia (female organs) on under side with egg in each at the base. In older specimens the sporogonium (capsule) may be studied. To study the mature sporogonium, the plants should be collected in summer (June or July). Just as the capsules are pushing through the curtains on the underside of the female receptacles, the plants may be preserved in formalin. In this condition they will keep several years for study.

ount a portion of the capsules containing the spores and elaters udy the latter.

### *Foliose liverworts*

**Frullania.** This is found on the bark of trees in damp woods; and be collected at any season of the year for the study of the vegetative . Note axis (which corresponds to the midrib of the thallose forms). overlapping, lateral leaves in two rows. Note the pockets on the inner r angle of the lateral leaves on the under side. Study the small leaves ing a third row on the under side of the axis. In this or some of the r forms of the foliose liverworts the sporogonia may be observed; also, n ripe, the four valves into which it splits; and lastly the spores and rs.

### MOSSES (muscineae)

1 Select a **polytrichum, mnoum, funaria,** or other moss which n fruit. Preserve dry and in formalin, or obtain fresh. Study leafy portion, the axis, three rows of leaves, the rhizoids; exine the leaves and the rhizoids with the microscope; notice the lked capsule, its attachment to the leafy portion of the plant, the yptra (remnants of the archegonium) if present, the lid (operlum), the teeth and spores. A section of a nearly mature caple will show the portion of the capsule which develops the spores.

2 Study the young male plants which have not yet developed fruit, noting club shaped antheridia. Study female plants with archegonia. The hegonia are flask-shaped and are situated on the end of the stem in the ecies selected. If **protonema** can be found study it.

## Pteridophyta

### FERNS (filicineae)

63 **Christmas fern** (aspidium acrostichoides) for example, may e taken or polypodium compared. The entire plant should be ollected and preserved dry. Any other fern may be selected and everal should be studied for comparison. Preserve some of the ems in 70% alcohol. Preserve mature sporangia just ready to open formalin if they can not be obtained fresh at the time of study. resh material for the study of the sporangia can usually be obined from conservatories as needed.

64 Study form and position of the stem (rhizome in several enera), the roots, leaves, fruit dots (sori), indusium when present, orangia and spores.

65 Mount some unopened but mature sporangia in water for microscopic examination. Draw glycerine under the cover glass and watch the effect on the sporangia through the microscope.

66 Compare the sensitive fern (onoclea) with one like adiantum. For study of the prothallia of ferns, select some prothallia growing on the soil of pots in the conservatory, or grow some by sowing the spores a month or two or three months in advance on damp earth in greenhouses, or grow under a bell jar in a room not in strong sunlight. Consult a gardener.

67 Study the germination of the spores, from material sowed about a month in advance, to see the formation of the protonemal thread and the rhizoids. Study mature prothallia from the older material. Mount some in water with the under side uppermost; study the rhizoids, the rounded antheridia situated among them, the longer archegonia near the sinus.

68 If the prothallia have not been watered for several days, one is likely to see some of the antheridia burst and the escaping spermatozoids swim around for several minutes. The teacher may section some of the prothallia to show the structure of the antheridia and archegonia; or permanent sections mounted in balsam may be used for demonstrations.

### HORSETAILS (equisetineae)

69 **Field horsetail** (equisetum arvense). Material may be preserved dry, and portions of the underground stem and some of the fruiting spikes in formalin. Both fruiting and sterile shoots as well as parts connecting with the underground stem should be collected. Study form of the fertile shoot, markings, the nodes and internodes, the fruiting spike with whorls of shield-shaped spore-bearing leaves (sporophyls), the sporangia, spores and elaters. Study and compare sterile shoot.

### CLUB MOSSES (lycopodineae)

70 **Lycopodium clavatum.** It may be preserved dry, or some of the fruiting spikes in 70% alcohol. Study the creeping stem, the roots, the leaves, the upright branches with the fruiting spike at the top. Study the spore-bearing leaves forming the spike, the single sporangium at the base of each, the spores all of one kind. Study, if there is time, other club mosses.

### LITTLE CLUB MOSSES (selaginelleae)

71 **Selaginella.** Some of these plants are grown in conservatories. When these can not be had, fresh material may be collected and preserved in for-

or alcohol. Study the stem and leaves of the plant, the spike, usually hat angled by the four or six rows of leaves arranged regularly. the spore-bearing leaves of the plant, each bearing in the axil a single gium; the lower ones large and containing few macrospores, the ones small and containing many microspores.

### QUILLWORTS (isoetaceae)

**Isoetes.** Material may be preserved dry and in 70% alcohol. n also be obtained from the Ithaca botanical supply co. Study eneral form of the plant; the roots and leaves; section longi- ally to see the form of the short stem; observe the broadened, apping leaves thick at the base, the sporangia in the bases of eaves, one for each leaf, each sporangium divided into several artments by cross walls. Study the two kinds of spores, the r ones (macrospores) usually in the outer leaves; the smaller (microspores) more abundant on the inner leaves. The micro- s are bilateral, the macrospores tetrahedral. Sometimes both are found in the same sporangium.

## Spermatophyta (seed-bearing plants)

### GYMNOSPERMS (naked seed plants)

**Pine** (white pine or other species). Use cones just at rity, before the seeds have scattered, dry. Male cones just at rity, before the pollen has scattered, can be preserved in 2.5% alin if they can not be obtained fresh for study. Collect in May lly. Young female cones can be collected at any season of ear and used fresh, or preserved in formalin or alcohol. Shoots ing the leaves may be collected fresh. Study the long shoots h arise in false whorls at the end of each year's growth, the leaves on them, the short shoots scattered over the long ts, bearing the tufts of long leaves (needles) with bud scales e base. Study mature cones; remove one of the cone scales, form, the seeds. Study a young female cone; its two parts; on the cone scale the ovules in the places where later the seeds ar. Study the male cones; tease open or section, one of the er sacs, the sporangia; study the pollen (microspores).

The teacher can prepare sections of the ovules at different stages to it the prothallium, archegonia, pollen tube entering, and the embryo. ycas plant in a conservatory can conveniently be reached compare it ferns. Other gymnosperms may be studied.

### ANGIOSPERMS (inclosed seed plants)

75 **Forms suggested.** Trillium, dentaria, caltha and others. Study stem (in trillium and dentaria a perennial, underground stem, with an upright, annual shoot), leaves (or scales in some cases), flowers, floral envelops forming the two outer whorls, calyx composed of sepals, corolla composed of petals. Compare the floral envelops with the leaves. Observe the spore-bearing members, stamens bearing anther sacs and pollen (microsporangia and microspores), the pistils (carpels) containing ovules (macrosporangia containing macrospores); compare stamens and pistils with leaves.

76 The teacher can here section ovules of different ages to show the embryo-sac (macrospore), the young embryo, and the formation of the seed, seed coats, etc.

## Studies of representative families of the higher plants

77 The following topics are suggested for the study of the characters which show the kinships among the higher plants, and the grounds for their union in different families. One or more species may be studied in each family according to convenience or time. If the plants can not be obtained in a fresh condition at the time needed, they may be preserved dry by pressing, and a number of the flowers of each kind should be preserved in formalin. Types of fruit, branching, and of the inflorescence can be studied along with the examination of these forms.

### MONOCOTYLEDONS

**Topic 1 Monocotyledons with conspicuous petals**

*Liliaceae:* LILY FAMILY

**Topic 2 Moncotyledons with flowers on a spadix**

*Araceae:* ARUM FAMILY (palms belong here)

**Topic 3 Monocotyledons with a glume subtending the flower**

*Gramineae:* GRASS FAMILY. Cyperaceae: sedge family

### DICOTYLEDONS

**Topic 4 Dicotyledons with distinct petals, flowers in catkins or aments, often degenerate**

*Salicaceae:* WILLOW FAMILY. *Cupuliferae:* OAK FAMILY

**Topic 5 Dicotyledons with distinct petals, and hypogynous flowers not in true catkins**

*lmaceae:* ELM FAMILY. *Ranunculaceae:* CROW FOOT FAMILY. *Cruciferae:* TARD FAMILY. *Geraniaceae:* GERANIUM FAMILY

opic 6 Dicotyledons with distinct petals, and perigynous or epigynous ers. Many trees and shrubs

*ceraceae:* MAPLE FAMILY. *Rosaceae:* ROSE FAMILY. *Amygdalaceae:* OND FAMILY. *Pomaceae:* APPLE FAMILY. *Papilionaceae:* PULSE FAMILY

opic 7 Dicotyledons with distinct petals and epigynous flowers

*nagraceae:* EVENING PRIMROSE FAMILY. *Umbelliferae:* PARSLEY FAMILY

opic 8 Dicotyledons with united petals, flower parts in five whorls

*acciniaceae:* WHORTLE BERRY FAMILY

opic 9 Dicotyledons with united petals, flower parts in four whorls

*abiatae:* MINT FAMILY. *Caprifoliaceae:* HONEYSUCKLE FAMILY
*ipsacaceae:* TEASEL FAMILY. *Compositae:* COMPOSITE FAMILY

## Oecology

Topics under this head can be taken up at different times during the year seasons most suited and convenient for their study.

### SEEDS

78 Study the form of different seeds; section some to note the parts, the m of the embryo, cotyledons, presence or absence of the endosperm, etc.

### DISSEMINATION OF SEEDS

79 In the summer or autumn study the different means by which seeds e disseminated, as in taraxacum (dandelion), hieracium (hawkweed), tuca (lettuce), asclepias (milkweed), clematis (virgin's bower), desmodium ick seed), bidens (bur marigold), pine, seed of fruits, etc.

### SEEDLINGS

80 Study germination, by placing seeds between the folds of wet paper r cloth, and by planting in the soil, of several different species, as corn, peas, eans, pumpkin or squash, etc., and compare the different ways in which the nbryo comes out of the ground, and also the different ways in which the dosperm is used. The castor oil bean is a good one to compare with the thers in this latter respect.

### LEAF ARRANGEMENT (phyllotaxy)

81 Study the arrangement of the leaves on the stems of different lants, whether opposite, whorled, alternate, and then whether of he 1-2, 1-3, 2-5, 3-8, etc. arrangement. This study can be car-

ried on at any season of the year, since lateral buds and leaf scars indicate positions of leaves. Study the relation of leaves to light.

### TWIGS, BUDS ETC.

82 Study growth of woody stems in thickness and length, as in the ash, oak, etc. Study buds. In the spring study opening buds and flowers, to see the arrangement of the leaves and parts of the flower in the bud; the transition from bud scales to leaves.

### POLLINATION

83 Study means for the dissemination of pollen and for carrying the pollen to the stigma of the pistil (pollination); wind pollination, self-pollination, insect pollination; cleistogamous flowers.

### PLANT COMMUNITIES

84 Study relationships of plants in communities; the kinds associated under certain conditions of soil, moisture, protection, water, temperature, climate, altitude, etc.

85 Association of plants, as in symbiosis in the lichens, indian pipe, etc.

Seasonal changes; the plants of different seasons in the same locality.

86 Struggle for occupation of land. Study plants as factors in retaining newly made land where washed by streams; occupation of deforested areas; reforestation of old lands.

87 Uses of plants in soil formation. Study rock vegetation, lichens, algae, as well as the higher plants; vegetation of moors, and filling of moors.

### ZONAL DISTRIBUTION OF PLANTS

88 On margins of streams, lakes, moors, etc., study the relation of different kinds of plants to depths of water and degrees of moisture in the soil. Consider their relation to age of soil or formation; also the arrangement of the plants in distinct zones, and the tension lines between the different zones.

GEORGE F. ATKINSON
WILLIAM R. LENNON } *Subcommittee on botany*
EDWARD S. BURGESS

## REPORT ON PHYSICS

ıe subcommittee on physics begs leave to report as follows: · various consultations and discussions, a provisional list was ıred, printed and 250 copies sent to high schools, academies seminaries throughout the state. In view of its apparently ·able reception, it would appear desirable to adopt it at least he present, and as a working basis.

e believe that the work of the subcommittee for next year ld be the preparation of a list of references and suggestions to npany the list.

ɔping that what we have planned, as well as what we have ac- ɔlished, will meet the approval of the committee and the asso- ɔn we beg to remain:

Very respectfully yours

William Hallock
Albert L. Arey
I. P. Bishop
L. C. Cooley

*Subcommittee on physics*

ıe following list of experiments was designed as a guide to : teachers who are quite at a loss to know what experiments ɔest adapted to laboratory work, and as a suggestion possibly, ıose more favorably situated, who have a wider experience to · on. It was not intended to fetter the individuality of the ɔughly qualified teacher in the least, but rather to aid those rtunate teachers who, without experience in laboratory physics, enly find it assigned to them to teach. Many good experi- :s have not been included in the list, though we hope all bad are excluded.

ıe list is intended to furnish more than enough work for the student in the best laboratories, thus leaving his instructor a iderable amount of latitude in the particular ones chosen. ɔably from two thirds to three fourths of the experiments could one under favorable conditions. The teacher may alter the ence or association of the individual experiments as may appear for local circumstances. The committee expect to prepare ıg the coming year, detailed suggestions concerning the ex- nents, together with numerous references to many textbooks manuals. Possibly details as to apparatus will also prove :able.

## Proposed list of experiments for a year of laboratory work

### MECHANICS

1 Estimation of tenths in measurements:
  *a*) measuring a distance shorter than the ruler;
  *b*) measuring a distance longer than the ruler;
  *c*) dimensions of a parallelopiped.

2 Measuring areas and volumes:
  *a*) of regular bodies by dimensions;
  *b*) of irregular bodies by comparison with the weight of a regular body (Worthington).

Micrometers and calipers to measure diameters of cylinders and spheres.

Levers, principles with meterstick, three-cornered file and weights.

3 Weighing:
  *a*) with meter stick and file;
  *b*) with equal beam balance;
  *c*) on a graduated spring balance;
  *d*) by substitution of weights on an ungraduated spring.

4 Density of regular solid $\frac{\text{mass}}{\text{volume}}$.

5 Specific gravity of liquids:
  *a*) tubes communicating above with ⊥;
  *b*) with bottle;
  *c*) by loss of weight of a body immersed in water and then in the liquid;
  *d*) floating rule;
  *e*) hydrometers;
  *f*) determining the capacity of a flask.

6 Specific gravity of solids:
  *a*) of a regular body;
  *b*) of an irregular body by immersion;
  *c*) substance lighter than water;
  *d*) calculating diameter of a wire from its length and specific gravity.

Calculating the mass of a column of air.

Construction and principle of the barometer.
  *a*) effect of elevation above sea level;
  *b*) principles and use of verniers.

Principle and action of:
  *a*) siphon;
  *b*) suction pump;
  *c*) other pumps.

Liquid pressure:
  *a*) downward;
  *b*) upward;
  *c*) lateral;
  *d*) below free surface;
  *e*) shape of vessel (Pascal).

Friction of rest and motion depends on:
  *a*) area;
  *b*) load.

Tenacity or breaking strength of wire.

Elasticity of bending; effect of:
  *a*) length;
  *b*) width;
  *c*) thickness;
  *d*) material.

Elasticity of stretching of wire; depends on:
  *a*) length;
  *b*) diameter;
  *c*) material.

Elasticity of torsion of wire or rod; depends on:
  *a*) length;
  *b*) diameter;
  *c*) material.

16 Elasticity of gases; Boyle's law.

17 Composition of forces.
  - *a*) parallel; with ruler and spring balance;
  - *b*) oblique; by constructing parallelogram.

18 Moment of rotation and pair forces.

19 Center of gravity of:
  - *a*) regular body;
  - *b*) irregular body by suspension.

20 Falling bodies, board and vibrating rod:
  - *a*) space proportional to square of time;
  - *b*) inclined plane;
  - *c*) ratio of force to acceleration.

21 Simple pendulum:
  - *a*) isochronism;
  - *b*) effect of length;
  - *c*) effect of bob;
  - *d*) determination of *g*;
  - *e*) reversible pendulum.

22 Work:
  - *a*) vertically;
  - *b*) inclined plane;
  - *c*) pulleys.

23 Equilibrium of bodies on:
  - *a*) level table;
  - *b*) floating.

24 Construction and interpretation of curves.

### HEAT

25 Testing a thermometer:
  - *a*) zero point;
  - *b*) boiling point.

26 Linear expansion of a solid.

parent expansion of water in glass.

rve of irregular expansion of water between 0° and 50°C.

pansion of gas:
- *a*) constant volume;
- *b*) constant pressure.

elative conductivity of solids for heat.

udy and illustration of convection currents.

enomena of boiling:
- *a*) formation of air bubbles;
- *b*) singing;
- *c*) evaporation;
- *d*) distillation.

pecific heat:
- *a*) of solids by mixture;
- *b*) of liquids by mixture.

Latent heat:
- *a*) of water by mixing with ice;
- *b*) of steam by condensation.

Relative humidity:
- *a*) dew point;
- *b*) wet and dry bulb thermometers.

Maximum and minimum thermometers.

Cooling by forced liquefaction:
- *a*) salt and ice;
- *b*) solution.

Newton's law of cooling by radiation.

## SOUND

Velocity of sound:
- *a*) out of doors;
- *b*) by resonance in tube with water;
- *c*) in rod.

40 Monochord, pitch of string depends on:
   *a*) length;
   *b*) tension;
   *c*) mass.

41 Pitch of tuning fork:
   *a*) by trace in lampblack;
   *b*) by comparison on monochord

42 Lissajou's figures.

43 Chladni's figures.

### LIGHT

44 Law of inverse squares.

45 Photometers:
   *a*) Rumford;
   *b*) Bunsen.

46 Laws of reflection of light from:
   *a*) plane surface;
   *b*) curved surface;
   *c*) focal length of concave mirror.

47 Refraction:
   *a*) with plate of glass;
   *b*) with prism;
   *c*) index of refraction.

48 Wave-length of sodium light with simple grating.

49 Focal length of convex lens:
   *a*) parallel light;
   *b*) conjugate foci.

50 Magnifying power:
   *a*) of a simple lens;
   *b*) of a microscope, telescope or opera glass.

### ELECTRICITY

51 Lines of force around:
   *a*) magnets of various shapes;
   *b*) magnet and soft iron;
   *c*) coil carrying current.

›tting a magnetic field in a room by swinging a bar magnet.

tic electricity:
- *a*) electroscope, gold-leaf;
- *b*) induction;
- *c*) relative potential when rubbed;
- *d*) both kinds always liberated.

:ctric batteries:
- *a*) different metals, same liquid;
- *b*) different liquids, same metals.

rsted's experiment on deflection of needle by electric current.

sistance:
- *a*) effect of length of wire;
- *b*) effect of diameter of wire;
- *c*) effect of material of wire;
- *d*) by substitution.

:asurement of electric current by:
- *a*) tangent compass;
- *b*) copper voltameter;
- *c*) water voltameter.

ctor of a galvanometer.

:ctromotive force (pressure) comparison by high resistance ınd galvanometer.

mbinations of cells for best efficiency.

:sistance determinations by the Wheatstone bridge.

:ect of temperature on resistance.

luced currents.

:termination of:
- *a*) current } by fall of potential.
- *b*) resistance }

›garithmic decrement.

66 Efficiency curve of an electric battery. (Polarization curve of a cell)

Will you kindly criticize the above:

*a*) as to whether any experiment listed should be omitted.
*b*) whether any should be added.
*c*) whether any should be changed.

The committee on physics have assumed that laboratory work by the pupils, is an indispensable part of a secondary school course in this branch of science. They assume also that all subjects are not equally adapted to laboratory study in physics. While certain subjects furnish materials for the most fruitful experiment, others in great number do not, and should be dealt with in the class room only. Therefore the first requisite for success with laboratory study in physics, as an educational exercise, is a judicious selection of laboratory topics. They have thought that the best service which they could render is the preparation of such a list and a complete outline of subjects for a laboratory course in the secondary schools constitutes their report.

They believe that the length of the course in physics should not be less than one full year. The outline of topics which they offer is intended to furnish more material than is likely to be used for the laboratory part of the year's course in physics even in the best equipped schools. It is not supposed that the entire outline will be completed in a single course. But from the maximum number given, the teacher can easily select two thirds or three fourths of the subjects, to constitute a satisfactory course for a year's work suited to his facilities.

They believe that a list of reference books on the subjects given in the outline with suggestions in regard to the method of conducting the experiments, should be put within reach of the teachers.

**Outlines of courses.** It will be noticed that each subcommittee have thought it wise to give a carefully constructed outline of the courses in the branches which they discuss. But it is not assumed that any one outline can be suited in every respect to the work of all schools. Local conditions must determine many details, and personality of the teacher must not be sacrificed. But, on the r hand, a general outline founded on sound principles and in- ing approved methods may be flexible enough to meet the ous conditions of the schools, and to give full scope to the viduality of every teacher. If such an outline can be generally pted it will tend to fix a uniform standard for science teaching. vill enable inexperienced teachers to reject many unprofitable jects and fruitless methods of instruction. It will focus the rts of the schools on one purpose, viz, to substitute for the sent chaotic practices a rational system of science teaching.

Ve believe that the outlines which we present do, in the main, ord with principles which are generally held to be funda- ntal, by the advocates of sound science in both schools and col- es. Can we not, for the present, overlook the details wherein individual opinions differ, for the sake of securing common und on which to organize a united effort to place science on a el with other departments as a serious and indispensable agent education? To make a stand on such common ground, even if area must be small, would start a reformation. Pioneer schools, e and there, have already blazed a pathway to the new secondary ence, and a concerted effort would speedily gather into it the ences of the schools throughout the state. After this, improve- nts and extensions would follow in due time, as determined by comparison of actual experiences.

**Thursday evening**

## SCIENCE AND THE NEW EDUCATION

BY PROF. CHARLES W. HARGITT, PH. D., SYRACUSE UNIVERSITY

The fairly familiar connotation of my subject, pedagogically eaking, renders it unnecessary to pause for definition, or to offer y apology for its use.

That there is in fact a " new education " is now so well recognized the consensus of educational opinion as to place the matter be- nd serious controversy. For just as emerging from the civilization of medievalism by an evolution, as real as that involved in the progress of life, the present splendid social and civil state has been realized, so by a similar process, no less real and potent, has been consummated a similar progress in both the aim and spirit of education. Account for it as we may, a profound and extensive change has taken place in the educational policy of our country, if not indeed of the world, within the present generation. Elective courses, new subjects, extensive libraries, finely appointed laboratories, with corresponding modifications of methods of instruction as well as subject-matter, all have been realized within this time. And along with these changes has come what, in the minds of not a few, has been appropriately designated as the "science of education"—the new psychology, the new pedagogy, the new point of view, the new ideal, the new spirit. And added to all this, are the growing place and attention devoted to technologic education, boldly proclaimed by educators of renown as contributing a culture not inferior to that of the so-called "liberal education."

The new education draws a sharp and significant distinction between mere information, or even instruction, and education proper. It does not even rest its definition upon the simple etymology of the term. It may seem a bit presumptuous to say that it finds the root of all education in the biologic laws and conditions which environ the plastic mind from birth, through the unfolding years of growth, making it the rational adaptation of the mental propensities to those conditions peculiarly its right in the order of progress, yet such are its grounds. In a recent address on the "Meaning of education," Prof. Nicholas Murray Butler has elaborated a cogent argument along this line, taking his points of departure from the doctrine of evolution, the significance of prolonged human infancy, and the consequent necessity for a corresponding period of graduated adaptation to changing conditions of environment, which he designates under the heads of science, literature, esthetics, institutions, religion. With rational adaptation to these elements of human environment the subject is educated. Without such he lacks that culture demanded alike by reason and nature.

rom an extended and critical study of the "Growth of the
n" Donaldson arrives at an essentially similar result on this
it, and states as a conclusion that "Education consists in modi-
ions of the central nervous system." As is well known, this
em, in size and development, is always precocious, every essen-
y nervous element destined to compose it being formed long
re birth. Following this event contact with external conditions
elops sensory experiences more or less rapidly, one after another
ction becoming coordinated into definite harmony with every
er for the good of the whole. Therefore he continues, "The
of living is thus the most important natural educational process
h which the human body has to do. . . The history of the normal
ividual is through various phases of unstable equilibrium and
kward strength, to the poise and quiescence of late maturity,
in any community examples of all these phases are found as
minal states in both young and old. The formal method (of
ication) therefore, which shall recognize in the presence of these
ormous differences in endowment, the dynamic value of the
ural inequalities of growth, and utilize them, preferring the
egularity to the roundness gained by pruning, will most closely
low that which takes place within the body, and thus prove most
ective."

And to the same point Pres. Eliot has recently borne testimony in
e following language: "A considerable change in the methods of
ucation has been determined during the past 25 years, by the gen-
al recognition that effective power in action is the true end in
ucation, rather than the storing up of information, or the cultiva-
on of faculties which are mainly receptive, discriminating, or
itical. We are no longer content, in either school or college, with
parting a variety of useful or ornamental information, or with
ltivating esthetic taste, or critical faculty in literature or art. All
ese good things we seek to be sure, but they are no longer the
ain ends. The main object of education, nowadays, is to give the
upil the power of doing himself an endless variety of things which
neducated he could not do. . . In a word, can he apply his in-
ormation and knowledge of methods to a problem which to him is

wholly unknown? Has he acquired not only information, but power? The whole field of natural science is available for that kind of training in power-getting which it is the main effort of modern education to supply."—*Educational reform*, p. 323

Similar testimony from widely different sources might be multiplied almost without limit, but it would be a work of supererogation to offer it in this presence.

True, there may linger here and there an isolated and benighted representative of the old who still hugs the obsolescent phantom of traditionalism; true, now and then a voice may break upon the scholastic air in arrogant denunciation of the new, or vehemently defending the divine rights of a " learned aristocracy," or demanding a " trained patriciate." Or it may break in bewailing despondency over the awful sacrilege which has mingled the fumes of the crucible with the odors of the "Attic violet," or it may even grow hysterical over the work of a " noxious, intoxicating gas " which has filtered through the crevices of a " scientific workshop," since it has awakened within mankind some realization of their inalienable rights and powers—theirs both by endowment and conquest—the right to know the truth and be guided by it, let the result be evolution or revolution, " conceived and led by the scientific spirit."

How sadly pathetic the fate which immolates such martyr spirits for sacrifice in a progressive age! Why should they not have been saved all this crucial agony by having had but glimpses of reality through the " magic casements " of some temple of ancient Jove, or learned " truth only about the past," with " calm science, recluse, ascetic, like a nun, not knowing that the world passes, not caring, if the truth but come in answer to her prayers! "

But despite it all, the " zeit-geist " rules quite otherwise, and the consensus of educational thought and practice accepts the modern view, and whether for better or worse, faces the dawn of a new century with an assurance not likely to be easily shaken or diverted, that the " new education " is a fact, vital and dominant!

Assuming this without further argument or emphasis, what of the relation of science to it all? It might seem hardly necessary to pro-

: serious argument upon this question in the presence of a body
:ience teachers. But a few statements of fact may not be amiss,
ing up our minds by way of remembrance and at the same time
ring our courage for work yet to be done.

t may not be amiss, for example, that we firmly recall that the
:alled scientific spirit is not a new thing in the world, any more
a that it must be created *de novo* in the mental life of every child.
d as it is native to every normal mind, so it is a heritage from a
iote past. And as the renaissance is known in history as the re-
al of letters, so likewise may the protestant reformation be said
iave been, in spirit, at least, a revival of the "scientific method;"
l both alike traceable by unmistakable lineage to the realistic and
uralistic spirit of the Greeks, who, more than any other ancient
ples, drew their best cultural inspiration from nature at first hand.
And no history of inductive science can any more ignore the work
Democritus, Archimedes, Aristotle and Galen, than that of Lin-
:us and Cuvier, Newton and Laplace. But its emergence from
: thraldom of medieval night has been gradual, and not till the
ening of the present century did it become sufficiently conscious
its sturdy strength and dare assert itself to effective purpose in
: formulation of the "scientific method." It is this *method*, so
:cefully designated by Huxley as the "method of common sense,"
iich has practically so revolutionized every phase of material life
at the world of today would no more be recognized by that of two
:nerations ago than does the present appreciate that millennial
topia of *Looking backward*. And what is true along physical and
aterial lines is hardly less true, though perhaps less conspicuous,
ong social, ethical and intellectual lines.

The insatiable inquisition for truth, and the irresistible assurance
iat this method only can finally discover it, has become the inspira-
on of every department of human thought, so that the scientific
iethod has become the working method of every progressive de-
artment of human learning. It is this which has turned the mind
om torpid introspections and empty speculations over elusive
agaries, to the recognition of the realities of time and sense, the

critical study of facts, and the inductive demonstration of the reign of law.

Prof. Jebb, a renowned classicist, with a clear apprehension of the spirit and method of science, and a candor equally conspicuous, has borne testimony to the subject in these words: "The diffusion of that which is specially named science has at the same time spread abroad the only spirit in which any kind of knowledge can be prosecuted to a result of lasting intellectual value."—*Pres. Eliot,* Educational reform.

Wherefore again, for better or worse, the scientific method has become the dominant factor in every phase of modern life, educationally, no less than otherwise. That it has been not only the promoter, but fundamentally the creator, of the new education, is at once the wail of the conservative defender of traditionalism, and the jubilant assurance of the prophet of the new dispensation!

Yet paradoxical as it may seem, the subjects of the method which has thus made possible a new education have had slow and scanty recognition at the hands of those who guarded the approaches to the ark of the educational covenant! The contention of science for a place among educational instruments has, till of late, been a veritable battle. Nor is it yet accorded coordinate value in many institutions, or even allowed elective equivalence as a condition for admission to institutions which have, in theory, granted its intrinsic merit and even sought its promotion.

That this statement is not overdrawn is abundantly shown in some comparatively recent educational movements. How did it come to pass, for example, that in assembling six educational conferences at Columbia university in order to consider the great question of equivalent college entrance requirements, science was practically the only great subject unconsidered? Commenting upon this rather remarkable circumstance, Pres. Eliot has said: "Pres. Low in organizing six conferences on requirements for admission to college in New England and the middle states did not think it worth while to have a seventh conference on science; because the institutions within the territory give so little attention to science as a requirement for admission, and so are divided as to the nature of the reement. It seems as if the time had come when we should gnize, if not among the prescribed subjects, at least among the tives open to candidates who present themselves for admission ollege, history, science, and the modern languages, and should a definition of science as a requirement for admission. I regret much that science was omitted from the recent conferences in York, because it is one of the secondary school subjects which st need be studied. A rational course in science—rational for the ool because it affords a substantial training in observing, record-, reasoning, and rational for the college, because it affords sound paration for further study in science during the years of college —is a great desideration."—*Educ. rev.* 11:418

Was this action in reference to the conferences a deliberate slight science, or simply the expression of a condition which made other tion inexpedient? I regret to have to confess that the latter was e more probable motive in determining the case, though to my ind without altogether warranting it. But whatever the occasion, the motive, the implication involved is unmistakable; as science achers we have not as yet achieved the full measure of our rights d privileges, nor met in full our obligations along this line. And ossibly the dereliction sustains a closer relation to the evident mitations forced on us than we have hitherto realized!

It may not be amiss in this connection to recall attention to the mphatic statements of Pres. Schurman made before this body at ts preliminary meeting in Buffalo, in which it was set forth in general that the preparatory work done in science was not of equal educational value with that done in language and mathematics; though softened somewhat by the cordial assurances pledged that whenever such equivalent preparation was assured its recognition on the part of the colleges would not be long delayed; an assurance since abundantly verified at Cornell university.

Science as such is no longer a mendicant. It has done apologizing for its existence, or its presence, anywhere. Having created from the universe veritable " new heavens and new earth," having placed them at the disposal of an applauding generation, whose time and energy it has so conserved that both the opportunity and taste for culture have become realities, it bodes no serious fears of a rightful and coordinate place in the affairs of men, whether civil, social or intellectual. In seeking recognition in the work of education it only frankly demands its rights and asserts its capabilities.

But the battle won on all essential points of educational fitness, it remains to secure for science teaching such conditions, both intrinsic and collateral, as will make practicable its just fruition. With its claims recognized, and a fairly respectable place attained in both school and college, the work in science yet lacks unity of purpose and method. Beyond the expression of sentiment organized in the program and discussions of the committee of 10, and the elaborate data secured by the later committee of the National educational association on uniform conditions for college entrance, nothing specific has been done toward bringing into proper order of relation and dependence the science work of the college and secondary schools. Speaking thus I have in mind primarily the prevailing conditions in our own state, yet they are probably not worse in this respect than those of adjacent states. But if this has been true of the past it need not necessarily remain so. With the extended range of subjects accepted for admission by not a few of our colleges, and the growing disposition on the part of secondary school officers to supply laboratory facilities for a larger line of sciences, and with an increasing number of adequately trained teachers for such subjects, certainly the time has come when a change for the better may be confidently expected.

In the light of the movements which grow apace for that coordination and correlation of subjects which tend toward uniform conditions for admission to college, as well as the largest results educationally, is it not high time that as teachers and representatives of science we should inaugurate a determined movement to secure similar results? Among the many ways which may suggest themselves through which much in these respects may be realized, three appeal to me as fundamental and practicable. For lack of better terms they may be designated as *coordination*, *correlation*, and *unification* of science work.

have long enough heard the invidious discriminations against nk of science teaching as contrasted with that of other subjects s to its matter and method. I have no doubt that in some the charge is quite sustained by the facts; but so much the for the facts; they remain none the less unpalatable! Nor is atter improved by the possible element of blame that comes to us in the reflection that we have possibly shown less con- han our colleagues in other departments, in the pedagogic s of our subjects. Have our pedagogic methods been strictly fic?

r there not be, moreover, the bare possibility of danger in the of self-security which we may have cultivated as to the all- ency of science to take care of itself in the schools as else- ? But whether we shall discover any such explanation of the s may afford adequate extenuation of the fault, or whether we hoose to find some grain of comfort in the reflection that are not so bad as they once were, it remains a fact that farther vement is within reach; and the spirit of the times and the con- s under which we live unite in demanding such coordination of subjects in the last detail of their educational bearings as will ly hush the voice of accusation and confession, but secure the possible advantages attainable thereby.

before indicated, the present offers no apologies concerning fic products or methods. They are the inspiring and controll- ctors of modern life. If thus in the every-day affairs of the ssive peoples of the world, why not in their education? If the has ceased to live and think according to the formulas of valism why should it continue to educate thus? It will not. hange is already upon us. Scientific education, in which e itself shall be a prime factor, is the demand of the hour and at the hands of its teachers.

t coordination of science teaching was not absent from the of the framers of the constitution of this association, is evi- for in article second occurs this language: "The object of ssociation shall be the promotion and *coordination* of science ng, etc."

But not only must there be coordination of subject and method, there must also be coordination in the time given to it. In the name of the conditions and demands which are upon us, it is both our right and duty to demand in turn from schedule committees and boards of direction, fairly equitable proportion of time. Is there any defensible reason why in the secondary schools there should be such a disproportion of time and attention devoted to language and mathematics to the neglect of equally worthy subjects, as the tabulated figures of the report of the committee of the National educational association show?

Under such conditions, with science stuck in here and there, like ciphers to fill up vacant places, and taught by methods and teachers equally unfit, is it strange that results were not satisfactory? Give to the live science teacher three or four years of continuous work with one, or with two or three cognate sciences, as physics and chemistry, for example, and then enter any comparison which may be chosen, and the science teacher will abide by the decision!

Again, let the colleges open the way by accepting equivalent work in science, thus recognizing its coordinate value, and see whether the schools do not respond. It is matter for congratulation that this movement on the part of colleges is growing. With Harvard, Cornell, Stanford and others leading, others still must certainly fall in line and keep step in the march of events!

But coordination should furthermore be secured not only with other subjects, but with the various subdivisions of its own. If for example, it be competent for this association to resolve that a minimum of one year shall be required in physics, and that the method should be thus and so, is it not equally within its province to similarly coordinate botany, or zoology, or chemistry? It is just such coordination in other subjects which made possible the consensus of sentiment in the Columbia conferences. And nothing less than this will secure for science similar recognition; nor would we ask it otherwise.

By correlation of science work I have chosen to designate, not so much that interrelation of science with language, or drawing, or other subject practicable to such, though this may be its more usual agogic significance, and I would not imply its incorrectness in h use, nor the improprieties of such correlation, specially in the er grades, but that interrelation and dependence of sciences themres, not only as to matter and method, but as well to their order sequence.

Why should there not be, for example, such correlations of the rious sciences that elementary courses in college science would no more thought of than would elementary courses in language mathematics? Why should it be necessary to devote the best rt of an entire year, and that too often the junior year, in learning e merest alphabet of botany or chemistry? Why not seek such rrelation of subjects common to school and college that an easy ansition from the one to the other would be realized? We have, am convinced, too long fostered the idea of the essential distinctss of these two institutions, which should in fact be but parts of a mmon system; and it seems to me that our education as such, ill never be really scientific till we have so correlated the several urriculums from the kindergarten to the university, that the passge from the one to the other, if not easy, will at least be natural nd rational.

I am not unmindful that there exists a certain belief, or impresion, in certain quarters, that an essentially different method of treatnent is necessary in preparing students in science for college, and n preparing them for simple graduation from the high school; that o the latter class the subject should be rather predominantly informational than experimental; that in a word, the one may be a *extbook* course, while the other must be a laboratory course.

For one, I not only do not share this idea, but hold a radically different one. It seems to me to proceed upon thoroughly unpedagogic, as well as unscientific, assumptions, contrary alike to reason and the spirit of the new education. From my own point of view, and speaking as a biologist, I should contend that, whether preparing the pupil for the college, or for the farm, or for neither, the work, both in matter and method, should be fundamentally one and the same. The end of such training in either case is scientific power, the capacity to direct the faculties upon any problem in a thoroughly scientific way.

In other words, whether for the school, the college, or in its application in the arts; whether it be taught for information, for discipline, or for culture, science must be genuine. We have certainly done with that obsolescent, one term idea, or with that pseudo-science which scintillates or sputters at capricious intervals in sundry test-tubes and bottles, displayed upon the teacher's desk, or in that still worse form which involves neither the one nor the other, but comprises odd anecdotes of dogs, or birds, or ants, which have hardly better foundation in fact than the fables of Esop, and of incomparably less interest, and therefore of less educational value. There may be a degree of value in the knowledge of the fact that the mean annual temperature of the Pacific coast is higher than that of the corresponding latitude of the Atlantic; but if in offering a reason for it the pupil responds, as did a candidate for admission to college in the presence of the speaker, " that the climate of the Pacific coast is warmer, because the sun is always hotter in the afternoon," it may be questioned whether its importance is at all commensurable with the educational perniciousness involved. If there be science instruction at all, let it be *genuine*, i. e., at first hand, and by a method which compels observation, discrimination, reasoning, judgment. If this be not practicable, better direct the time and energy upon other subjects, even though they lack informational value, and train indifferently, if only they be not immoral!

On this point Prof. Huxley long ago bore testimony in no uncertain sense in the following words: " No boy or girl should leave school without possessing a grasp of the general character of science, and without having been disciplined more or less in the methods of all science, so that when turned into the world to make their own way, they shall be prepared to face scientific problems, not by knowing at once the conditions of every problem, or by being able at once to solve it; but by being familiar with the general current of scientific thought and by being able to apply the methods of science in a proper way when they have acquainted themselves with the conditions of the special problem."

But if it should even prove that in special cases the informational aspects should have fuller consideration in the one case than in the er, a variety of ways might be easily devised by the live teacher which to meet them, such as topics set for library work, or special sions held for reports, or discussions upon collateral subjects, if this were not practicable in every case, then an added course the student preparing for college, which, with the elective system ried into the high school, is certainly practicable and logical.

A correlation such as indicated could only become efficiently erative under some scheme of supervision, or through a consensus opinion such as that secured by the Columbia conferences. That th are possibilities within the scope of this association, at least in asure, seems to me a not extravagant assumption; for if I am able read the signs of the times, such is but the logical outcome of esent educational movements.

With a rational correlation secured in the work of college and condary school courses, its extension to the grammar and element- y grades in the form of nature study would culminate in that ification of our educational system which would secure for the hole a definiteness and symmetry, as well as perfection, the lack of hich is at present its most serious blemish, which could not but sult in an enrichment of educational fruition such as we have ardly guessed hitherto. Without such we shall likely continue uch as at present. That we shall by degrees secure better science aching in the schools no one can reasonably doubt. But it would ack that coordinating spirit and motive which give meaning and alue to the scientific method. As intimated before, the whole sys- em, from the elementary school to the university must be organized round a single, great coordinating idea. And just in so far as we all below such idea, or fail in its practical realization, is our system ot only unscientific, but imperfectly educational.

To the possible charge that all this is vague and visionary, it is sufficient to say that it has had abundant application and verification in schools and colleges, east and west. Long ago the Society of naturalists formulated such a correlated scheme of science work and its trial has proved its merit. Again, the report of the committee of 10 is such in fact, and practically attested by an extended adoption. Furthermore the report of our own committee of nine expresses a cases, but is nearly always based on the subject as given in Martin's *Human body*, or an equivalent textbook, and in some cases this requirement is placed along with the elementary requirements for admission, while the other sciences enumerated are usually placed in the group of advanced admission requirements. The institutions are the following:

University of California (1897-98), physics, chemistry, botany, zoology

University of Chicago (1897-98), chemistry, physics, botany, zoology, general biology

Columbia university in the city of New York (1897-98), physics, chemistry, botany

Cornell university (1898-99), physics, chemistry, geology, botany, zoology

Harvard university (1897-98), physics, chemistry

Johns Hopkins university (1897-98), chemistry, botany

University of Illinois (1897-98), physics, botany, chemistry, zoology

University of Indiana (1897-98), chemistry, physics, zoology, geology, botany

University of Iowa (1896-97)—subjects named in order of preference—physics, botany, chemistry, zoology, geology

University of Michigan (1897-98), physics, botany, chemistry

University of Minnesota (1897-98), physics, botany, zoology

University of Nebraska (1897-98), botany, chemistry, physics

Oberlin college (1897-98), botany

University of Pennsylvania (1897-98), physics

Leland Stanford jr university (1897-98), physics, chemistry, botany, zoology

Syracuse university (1897-98), physical geography, physics, botany

Wellesley college (1897-98), physics, chemistry, zoology

University of Wisconsin (1897-98), physics, botany

Yale university (1896-97), botany

Botany and zoology are offered by eight, University of California, Chicago, Cornell, Illinois, Indiana, Iowa, Minnesota and Leland ırd. One, Wellesley college, offers zoology but not botany. offer botany but not zoology, namely, Columbia, Johns Hop-Michigan, Nebraska, Oberlin, Syracuse, Wisconsin and Yale. 5 offer botany, 15 physics, 13 chemistry, eight zoology, three ;y and one general biology. Oberlin and Yale offer only r. At Yale Gray's *Lessons* are recommended as a suitable aid paring for the examinations; while at Oberlin, Gray's *Lessons*, ı addition Gray's *Manual* for the identification of flowering , are recommended. At Johns Hopkins Spalding's *Practical* , excluding the microscopic work, and Gray's *Manual* for the ication of species of flowering plants, are recommended. At niversity of Iowa not less than two terms in each science are :ed, but one term will be accepted when combined with other :ts. At Syracuse a "full half year" course in plant structure evelopment is required. At Wisconsin the equivalent of two work is required in anatomy and physiology of plants and the ncement is made that this will be increased in 1898-99 by ad-al work on the lower plants. At the University of California, rsity of Chicago, Columbia university, Cornell university, rsity of Illinois, University of Indiana, University of Michigan, rsity of Minnesota, University of Nebraska and Leland ord jr university, it may be inferred from statements in the ers, the requirement in general should represent a year's work school. In a number of cases there is no definite statement s effect, and the aids suggested might admit the acceptance of ıan a full year's work. In some cases the statement is made ıe requirement is expected to be the equivalent of a full year's in the high school with four or five sessions a week, of three s to one hour each. In Columbia university the further speci-ın is made that the work is to represent a detailed study of 40 . At Cornell university a minute statement covering a page half of the register is devoted to describing in detail the cter of the study, and giving the names of the plants suggested m the basis of the work, though other plants illustrating the sets of conditions would of course be accepted. At Cornell no element is specified but botany as well as physics, chemistry, geology and zoology is allowed in lieu of advanced mathematics and the study is expected to equal that of advanced mathematics in difficulty and time of preparation, while it is understood to require a full year for preparation. In nearly all the institutions named practical work along the lines of modern methods of science study is required, and in many cases it is explicitly stated that note books containing a record of the observations, approved by the teacher, will be required at the time of examination as evidence that the practical work has been faithfully performed. In Yale and Oberlin the subject may be considered as one of the elementary requirements.

In some cases all entrance requirements represent one or more units, and the student has the option of choosing a certain number of units to present for admission. In other cases the science subjects are included in certain groups of subjects required in full, or one or more may be presented in lieu of Greek or of a modern language, or an option is offered among several science subjects.

This makes a strong showing for a number of institutions in acceptance of the natural sciences either for admission to certain courses or as units in making up the admission requirements in certain entrance groups. It is desirable perhaps, that greater uniformity prevail among the universities in the character and amount of study required for a subject unit, and that the number of science subjects offered be increased in some institutions.

But the important question is, Can the schools meet these requirements, and what can we do to indicate definitely the specific requirement in the way of outlines or synopses of courses? The committee of nine of your association, appointed nearly two years ago and continued last year, has considered the formulating of some plan for the betterment of science teaching in the secondary schools. A year ago the committee was directed by the association to form subcommittees representing various science subjects, and invite cooperation from outside in preparing outlines of courses for study in the schools. I believe the committee has not been successful in preparing such an outline for zoology. The subcommittee on botany has made its report to the chairman of the committee of nine, and this is included in his report presented to the association yesterday.

n the preparation of this outline several things were kept in view.
election of topics that are reasonably within the reach of the
ools, that will require some special pieces of apparatus, not very
ensive, and will, while not demanding the severe tests of univer-
research, familiarize the schools with modern methods of science
dy. 2 Provision for a full year's work, that does not overlook
schools where only a half year can at present be devoted to the
bject. 3 Arrangement of the subdivisions of the course in such
der that the season of the year will not prevent the obtaining of
od material, and such introduction of topics as will present the
ndamental principles of the science. The subject matter is so ar-
nged that it can be grouped under four general subdivisions: life
ocesses of plants, or physiology; representative plants of the great
oups, or general morphology; representative families among the
giosperms for classification, or special morphology; outdoor
udies on the mutual and environmental relations of plants, etc., or
ecology.

The last subject is not very susceptible of a practical and syste-
atic treatment by the student in a secondary school. The topics
ere are intended mainly to interest the teacher and pupil in the out-
oor relationships of plants. The inability of teacher or school
oard to control meteorological conditions, together with the neces-
ity of systematizing the periods of most studies, makes it impossible
o lay out a feasible, systematic course in oecology for the beginning
tudent of the secondary school which would satisfy the armor-clad
otions of the university professor. On suitable occasions when the weather and the school boards will permit, excursions should be made into the surrounding country, or into plant gardens or planted areas, for the purpose of studying seed distribution, adaptation of plants to conditions of the seasons, to variations in the soil and to moisture, the effect of environment on plants, and the effect of plants on environment. The students can find an interest in these things and be benefited by the association with nature without being learned ecologists. What matter if they do see some beauties of nature during these excursions? What harm can follow if they do associate some poetic thought with the environment where they

meet a freer and natural atmosphere of beauty? Only a small percentage of the students of secondary schools will ever enter the university's rigid courts of research. The memories of these experiences and the truths they yield will cling long after laboratory methods are forgotten. There is a chance to shut out poetry in behalf of system and logic during the larger part of the work given to the first three subdivisions, physiology, general morphology and classification. In these subjects we should emphasize the necessity for careful study and a record of observations. Here the methods of study by induction of facts and drawing of conclusions can be inculcated.

While the order in which these subjects are outlined need not necessarily be strictly observed in all cases, it will generally be found the best arrangement. The vegetative life processes can be well studied during the autumn. The subject is a good one to begin the year with, since the more general life processes are interesting to the beginner and can be demonstrated in an instructive manner. In the studies of protoplasm and the process of absorption some of the lower plants can be employed with advantage. These can easily be obtained in autumn in a living condition and one must have living material for this study. An examination of the lower as well as the higher plants shows that the life processes are more or less fundamental in all plants. At the same time the pupil is learning something of form and structure. While any time of the year is suited for study of general morphology, there is less difficulty in taking up studies of representative plants of the great groups during winter than would be encountered in dealing with the other subjects. Studies in general morphology can well be carried on with dead and preserved material. Then, springtime is far better than either autumn or winter for studies of special morphology and classification. The flowering plants are best suited for studies of representative families and the principles of classification, where relationships of species and genera are sought. In spring living material of most types suitable for study is abundant.

The study of the vegetative life processes, or physiology of plants, is concerned largely with function. Since some knowledge of form st accompany a study of function, the pupil gains by necessity ne knowledge of morphology while studying life processes. rthermore in this study emphasis is laid on the broader and more neral phenomena, like osmosis, absorption, diffusion, turgescence, trition, carbonic acid assimilation, respiration, growth, and irri- bility, rather than the less important and more special phenomena adaptation. The first lessons are practical studies of protoplasm, nce this substance is fundamental not only to the physical phe- mena of absorption etc., but to the life processes. The algae, ngi, liverworts, mosses and the higher plants are employed, to ow that these processes are fundamental. Incidentally, however, e pupil is becoming acquainted with a number of plants of which robably he has known nothing.

Next comes general morphology, not morphology in the special ense of organography, but morphology in the broadest sense, tudies of representative plants of the various groups, with their life istory, reproduction and relationship. The groups are taken up in he following order: algae, fungi, liverworts, mosses, ferns and their ind, gymnosperms, angiosperms. It is considered the natural se- uence to proceed from the lower and simpler plants to the higher nd more complex. Some educators, with a measure of reason, point to the difficulties which are met in beginning the study of representative plants of the different groups at the lower end, i. e. with the lowest and simplest plants, because they are usually entirely unfamiliar to the beginner. The difficulties are met in endeavoring to learn names, form, processes, and classification of a considerable number all at once. These difficulties arise, I believe, not because the plants are entirely unknown, but because too many unknown things are studied at once. The pupil attempts not only to make the acquaintance of the unknown plant, but to study its form, manner of growth, nutrition, reproduction and classification, so that he is bewildered by the large number of new facts not closely related. I have found that it is immaterial at what end of the series the young pupil begins; the difficulty is the same when the lower plants are reached. To obviate this the study of the vegetative life processes is introduced first, and the lower plants as well as the higher are employed for the practical study; a method which in my experience has been highly successful. It gives a familiarity with a number of the lower plants, and when the studies in morphology are begun, the student finds in many cases that he is dealing with known objects. In the study of plant families among the angiosperms one or more plants in each representative family are taken, the number depending on the time at command.

The outline suggests lectures and laboratory talks, supplemented by demonstrations before the class on the more difficult phases of the work. On the part of the pupil it calls for practical work, with some use of the compound microscope and other apparatus, the recording of observations and drawing of correct conclusions. In schools where only half of the year can be devoted to the study at present the outline can be adapted by selecting the central topics, which are printed in large type. By this means even in the shorter course the principles of the science and the methods of its pursuit will be gained. Following this method, the student acquires a knowledge of the fundamental laws and principles of botany. The topics are so arranged that in physiology they represent progression of function, and in morphology progression of form. At this point the student is ready for advanced studies in various lines, or for studies related to agriculture and horticulture. But those, who like the majority in the secondary schools, will never pursue the subject farther, will have gained some knowledge of the fundamental principles of plant life and plant relationship which will aid the mind in adjusting itself to modern science and modern thought.

When the work is thus conscientiously carried on for a year, with the usual amount of time given to other subjects of the secondary school course, it will make, I believe, a satisfactory unit of admission to college or university. This unit represents a piece of work approximately equal in difficulty to the more advanced requirements. It represents an equal amount of preparation in time. It represents continuous work, in which for a considerable time the pupil deals with related topics and the successional development of a theme. This method makes a more lasting and beneficial impression on his faculties than is possible when a number of scraps from ferent science subjects are combined. For these reasons I believe at a year's work in botany should stand for a unit of admission, d a year's work in zoology should stand for a unit of admission, d that a half unit in either one, or two half units one from each, ould not be accepted for admission; but this would still leave it en to departments in the university or college to give credit for rts of a unit when the student is admitted on other grounds, proded the work is found to cover adequately any part of a course fered in the university.

**Prof. A. D. Morrill**—The value of training in observational ience can best be appreciated by attempting to impart to persons ho have studied only language, a little mathematics and textbook cience, some understanding of the way in which scientific facts are etermined, or to enable them to use the facts which are the fruits of esearch. Training in natural history observation is needed by those who will enjoy the advantages of the college and university and the arger number who will early devote themselves to earning a living. Without it there can be no perfect comprehension of theories, born of evolution, which are permeating all knowledge and form to so arge an extent a basis for correct living. It is not to produce specialists but many sided men and women that we should educate.

The botanists and physiologists have definite plans for their subjects in the high school, and it is hoped that the zoologists will present equally well considered plans in the near future.

**Prof. Francis E Lloyd**—It is impossible to discuss fully each point in the able paper of Prof. Atkinson. I would advocate the construction of courses from two points of view, so that the conceptions of teachers of real ability may be met; for as the standard of teaching is raised and teachers of ability take the lead more and more in secondary work, we must give increasing consideration to their points of view.

The value of botany in high school and schools of a similar grade should be emphasized, for the subject leads to many important economic principles. The intelligence of the citizen can be determined very definitely by his attitude toward this instruction.

It is agreed that the work of the course should consist of a thorough grounding in plant morphology and physiology, embracing a study of protoplasm, its characteristics and activities, on the one hand and oecology on the other.

**Dr Frank M. McMurry**—Several speakers have spoken of the projected one year course as logical and well arranged. I wish to ask whether its excellence is due to the fact that it is more logical than courses heretofore presented or is less logical. In the discussion on biology for the high school at yesterday's session the older books were to some extent condemned; e. g. Boyer's and Colton's. As I remember, Boyer's book owes its supposed strength partly to the fact that it begins with the lowest forms of life and moves logically upward to the higher, but Prof. Davenport seemed opposed to such a careful arrangement of matter, suggesting that types be selected which are closely akin to the interests of the students. He seemed to suggest that progress consists in movement away from the strict logical order rather than toward it. I would be glad to know whether those present agree that we want less of the strictly logical arrangement rather than more of it in a high school curriculum in science.

**Prof. George F. Atkinson**—I do not think we should set aside the teaching of the fundamental principles of botany, and introduce first technical studies like forestry. The principles of botanic science come naturally before forestry studies. Some studies of trees and of general principles of forestry can be introduced under the head of outdoor studies, where the teacher is left to adapt the work to the conditions of the country which can be reached. Occasions like arbor day also serve to direct the public mind to the importance of forestry, but real forestry studies can be given only at technical schools established for the purpose. Studies in agriculture and horticulture have as great a claim on the secondary schools as forestry. What the agriculturist and forester want is to know how plants grow, how they obtain their food, how the general and fundamental life processes in plants are carried on, as well as to have a general survey of the plant kingdom, for agriculture as well as forestry is dependent on a knowledge of the lower plants as well as the higher. Then too in this study of the general principles and laws of plant life and plant relationship, we shall differentiate to some extent the methods and aims of study in the secondary ools from those of the primary schools, where the study of nts relates more to external form and the more prominent anges in the transformation of the individual plant during germi- tion, growth and fruition.

In reply to the query whether the course is arranged so that sub- cts are taken up in " logical " order, and in reply to the objections ised against this method of " logical treatment," I would say that e subjects are arranged in a logical order, so arranged that the rst step helps to interpret the second, and each succeeding step elps to interpret the next. The word " logical " is not the best to se here, but a course of study arranged so that each step helps to terpret the succeeding step, or steps, is the right one, whether e call it " logical " or not.

**Prof. Fred Z. Lewis**—For a course in botany, such as should e given in a high school, I do not believe that much attention hould be paid to classification of plants. I think that little real ood can be derived from tracing out the scientific names of 100 lants, more or less. It is well enough to teach the student how to use a botanical key and have him trace out a few plants so as to assure himself that he knows the method of procedure, whenever he may, perchance, desire to find out what is the scientific name of a certain plant. I believe that we should start with the study of a simple cell, such as protococcus, since the cell is the unit of all life; then take up some such form as spirogyra, which represents a union of cells in one direction; then some form which represents growth in length and breadth; and finally study the more complex form of plants, having cells extending in the three directions.

Thus the student will be able to understand increasing complexity of structure and the necessity for, and function of various kinds of plant tissue, which he has had an opportunity to study. He will also learn how the different cells arise and the changes occurring in them as they become older and farther removed from the actively growing part of the plant.

At the same time, the fundamental principles of reproduction should be studied; simple cell division in protococcus; conjugation and the formation of the spore in spirogyra; alternation of generations in the higher plants, etc. Pupils count sepals and petals, stamens and pistils, and know very little about the reproduction of plants. Let us teach as fully as possible, structure, function, reproduction, and those features which bear upon the great principles of life. If we proceed along such lines, I believe that we will find that our students will take greater interest in the work and derive more good from it, than they would from tearing plants to pieces merely to be able to hand in to the teacher the scientific names of a large number of plants.

### PHYSIOLOGY IN THE HIGH SCHOOL

BY JAMES E. PEABODY

Printed in New York Teachers magazine v. 1, no. 2, p. 163-70 (F 99).

### METHODS OF TEACHING BOTANY IN THE GIRLS HIGH SCHOOL OF NEW YORK CITY (MANHATTAN)

BY MISS IDELETTE CARPENTER

Printed in New York teachers magazine v. 1, no. 3, p. 205-11 (Mr 99).

## Section B. EARTH SCIENCE

### ABSTRACT

**Prof. R. E. Dodge** introduced the discussion of the subject, "What should be taught in a one year course in physical geography in the first or second year of the high school, and how it should be taught," by presenting the part of the report of the subcommittee of the committee of nine which refers to this matter. He thus defined the standpoint of the committee. A course in physical geography should include a study of the more important features of the earth, water and air environments of man, separately and in their relations, particularly as influencing the distribution, habits and customs of man and affecting other forms of life. The greatest stress and time should be given to the study of the land, man's most important environment. The question whether physiography or physical geography should be used as a title is not worth fighting over, though the committee prefers the latter term. The interest and disciplinary value of the subject can be assumed without argument. Such a course as is planned can be pursued successfully without any previous study of science, though it would be well that a course in physics should precede. Pure astronomy, biology and mineralogy should not be included, and there should be no attempt to teach completely meteorology, oceanography, or "geo-morphology."

e work should be logical and progressive, a unit in aim, and ıse and effect should be key words. The aims of such a course : to give a knowledge of the earth forms, their origin, classifi-:ion, and relation to life, together with the influence of climate, d the oceans; to train in scientific thinking and spirit; to impart lture and practical knowledge, not to train scientists.

The committee recommends that in New York state the ıdy be pursued in the first or second year of the high school, :cupying at least three hours a week for a year, at least one hour :ing devoted to laboratory and field work. The order of subjects be considered is immaterial, provided the plan be logical and :ientific. The laboratory and field work should be devoted to mple problems, comprising more than a mere explanation of pre-ous lectures or talks. The accompanying plan should be used as basis of discussion. The committee is of the opinion that such 'ork can be carried on with simple equipment, that is not very xpensive, and that New York state is an unusually fine center for eld work.

[For a statement of the exact subjects that the committee desires ɔ see included in such a course, see the report of the subcommittee ɔn earth science to the committee of nine, p. 494.]

The second paper was presented by **Ezra W. Sampson,** teacher ɔf physiography in the mixed high school, New York city, who levoted his attention particularly to what can be done in laboratory, ield and textbook work. Mr Sampson introduced his remarks by a statement of the equipment of the New York city high schools for this work, followed by a list of field excursions about New York that he has found very helpful; and then offered the following plan:

### Formal textbook work

1) Earth as a planet; 2) the atmosphere; 3) the sea; 4) the land; 5) weather and climate; 6) distribution of life.

**Earth as a planet.** 1) Solar system; 2) form and size; 3) movements; 4) magnetism; 5) mariner's compass; 6) latitude and longitude, maps; 7) internal conditions—hot springs, geysers, volcanos, earthquakes.

**The atmosphere.** 1) Composition; 2) weight and pressure, barometer; 3) heat of the atmosphere; 4) circulation of the air, cyclones, anticyclones, winds, calms; 5) storms, kinds, causes, laws, forecasts; 6) moisture of the atmosphere, evaporation and condensation, dew, fog, mist, clouds, rain, snow, hail, distribution of rainfall; 7) ice, glaciers, icebergs; 8) electrical and optical phenomena.

**The sea.** 1) Extent and divisions; 2) composition of sea water; 3) temperature; 4) depth; 5) deposits; 6) life; 7) ocean floor; 8) waves, tides, currents.

**The land.** 1) Extent, arrangements, divisions; 2) land forms, horizontal, vertical (or relief); 3) crust of the earth, minerals, rocks; 4) weathering, erosion, denudation, transportation of waste; 5) plains, kinds, causes, uses; 6) plateaus; 7) mountains; 8) valleys, kinds, formation, uses; 9) rivers, drainage, basins, divides, work of streams, uses; 10) lakes; 11) springs, wells; 12) islands.

### Laboratory work

**Problems,** i. e. something to be determined in a quantitative manner. Study of globes, maps, charts, folios, photos, slides, lantern, microscope, models, mineral specimens, rock specimens, construction of maps, profiles, etc.

**Meteorological work.** Weather maps, reading of maps, construction of weather maps, predictions from weather maps. Barometer: principle, construction and use, pressure and altitude, barograph records, seasons, etc., pressure and weather, cyclones and anticyclones. Anemometer and wind vane: wind (observations), velocity, day, season; direction, day, season; fair weather, foul weather, wind and weather, connection between. Psychrometer (observations): principle, construction, use; humidity, different times of day; humidity and different winds; dew, conditions of formation; frost, conditions, times, places or localities, fruit regions. Clouds (observations): types, origin, changes, upper, lower, movements, direction, velocity, both kinds; uses of clouds. Rain gage (observations): principle, construction and use; amount of rain and temperature, wind, seasons, showers; duration of periods of rainy weather; amount of rain and other weather elements, such as are given by other instruments; hail, sleet, snow, etc. Thermometers: various kinds, observations; extremes and mean, day, month, season, etc.; altitudes, solar radiation, soil. Thermometer and other weather elements. Comparison, or correlation of results from the different instruments.

**ote books.** Kept by all, but not all of same contents. De-
ptions, drawings, sketches, diagrams, tables, calculations to be
uded; truthfulness, neatness, good penmanship, good English,
rect spelling to be insisted on; dates to be given, margins to be
at top, sides, bottom; proper headings, ruling, lettering of
grams, and index to be given; individuality to be important
ure of work.

**mphasis of work.** Connection between all topics studied and
ditions of human life. Settlements, industries, commerce, rational
planations of the causes of phenomena and facts studied. The
w terminology to be taught: coastal plain, peneplains, dissected
teaus, cycles, youth, maturity, old age, rejuvenation, drainage,
ides, accidents to rivers, glacial phenomena, etc. Local features
died with care.

**" Method."** Methodical, systematic, orderly arrangement and
atment, with clearness and distinctness of statement. Least pos-
le talk by teacher; pupils to talk and illustrate at blackboard or
ate globe; full explanations brought out by proper questions;
here possible, present things put first—outdoor work preceding
xtbook work, e. g., glaciation, osars, kames, drumlins, pot-holes,
nk holes, erosion, sorting by running water, etc. After field and
boratory work much discussion, many questions. Recitation on
signed topics; connected statements, not scrappy, short answers.
upils to use figures and diagrams freely in their recitations, and
oint out on map features to illustrate statements. Work arranged
o as not to overtax the pupils, but to come very close to their
mits. Cultivate individuality, encourage pupils to exertion, ap-
reciate and reward efforts, giving hints as to voluntary observa-
ions. Hold private talks when possible; do not despise informa-
ion. Do not oppress or repress, nor allow the work to become
edious. Give training in both oral and written expression; and
reserve a judicious combination of laboratory, textbook and refer-
nce book work. Aim to make independent, rational, self-respect-
ng men.

The third paper, by **Miss L. Belle Sage,** of the Olean high school,
ere follows.

Prof. G. S. Williams, of Cornell university, aptly expressed the
entiments and motive of all teachers of science when, in an address

before the state association of teachers at Saratoga, in 1892, he said, "It will be observed that the keynote of the whole matter is direct contact with nature, and a diligent study of what she has to teach through the proper use of trained senses. Through these, important vitalized centres, or in Herbartian phrase 'apperceiving masses,' are gradually formed to which all later acquisitions naturally gravitate, like to like. And when we consider how deeply the results of early habits of observation affect all the higher uses of the intellect, and how frequently through their lack, the results of the highest intellectual and spiritual efforts are clouded by doubt or vitiated by error, we can but be surprised that so little definite attention has been given to this *primal* source of knowledge."

Even the children of the country districts, who pass their lives surrounded by the most varied scenes of nature, are as Whittier has said, "blind to the beauty everywhere revealed." No branch of science seems so well fitted to open the eyes of our students to the beauties of nature, or to arouse curiosity to pry into her secrets as physical geography; for does it not bring them in touch with rocks and minerals, show them something of the nature of plants and animals, teach a little of the mystery of the stars and connect all with cords of physical and chemical laws?

As a first year subject in our high school curriculum, physical geography must be regarded as intermediate between ordinary geography and the mother sciences; subsequent to and supplementary to the former, introductory to the latter, a connecting link binding both together. Alexander Bain, of the University of Aberdeen, has said, "The teacher is tempted now and then to bring under the proper or descriptive geography the scientific explanations of physical geography. Any such explanations should be very short and allusory; the two departments should be by no means intermingled." Some teachers would criticize the eminent professor, while many follow his teachings, and the student in ordinary geography takes the physiographic features of the earth as the book describes them, and seeks no explanation. He learns the names of mountains with comparatively little thought of their formation; the direction and flow of rivers and their tributaries with no question as to why the rivers took these courses; and locates cities with no suspicion that nature destined the rise of a people in that particular spot. Now if confine the study of physical geography to a mere description of surface of the globe, teaching effects without seeking their ses, we have no right to call the subject science in the true sense the word, for such instruction is no more scientific than the re recital of an incident which one has witnessed. So the h century teacher aims to make direct and personal observa- the very essence of all her work in physical geography, urging student to seek causes for the effects he sees in nature, using textbook to verify and correlate what has been observed.

Different localities furnish different subjects for specific study, t the local knowledge which the Germans aptly call "knowledge the home" is the best key to the wider study of the globe. Sup- se in beginning the study of physical geography that the teacher ce his pupils to visit a quarry, a sand bank, a beach, or best of all, rhaps, the head stream of some river. Here the brook has cut rough the shale, the rocks are breaking off in planes of cleavage, e stream shows evidences of having changed its course. A pot- le cut in one place, or markings on certain pebbles show the fects of erosion, while the soil on either bank illustrates the effects weathering. The teacher easily arouses a little rivalry among s students in collecting specimens, for it seems instinctive in ild nature to collect, and the class returns from the excursion ith enthusiasm and material enough for many weeks' work. The ecimens gathered, supplemented by the laboratory collection give e students a good idea of the composition of the crust and the rmation of rocks. As this study is continued, eagerness is roused in the student, actually to see how water and atmosphere ause the markings on the rocks, crumble and wear them, and hen how water arranges the particles in layers. So the first good ainy afternoon let the class don rubbers and mackintoshes and go o some sloping field or nearby roadside drain, and there let nature nswer their questions, while they see how whole continents are ade and unmade. Watch the water sifting the finer particles from e coarser, dropping the latter immediately, but carrying the former rward. Follow the roadside drain where it enters a pool or pond, nd see how it drops the pebbles directly at the entrance, and then he sand, while the mud particles are kept for deposit in the still ater. Thus may be demonstrated the method of the formation of deltas, of sandy and pebbly shores, and indeed, we might say of the vast tracts constituting the larger parts of our continents, for children, when brought into contact with nature, are quick to notice her infinite variety, and to correlate and classify, though crude may be the primary classification. Generalization, induction and the training of the judgment have their beginnings in the observation of these physical phenomena.

There is another side of physical geography which we must not shut out, that is the experimental. Many subjects, specially the atmosphere, can really be explained only through the laboratory. Even if individual work be not considered advisable for first year students, the experiments may be so arranged by the instructor that the student gains almost as much as if he had performed them himself.

Written explanations and careful drawings are good tests of the pupil's powers of observation and interpretation, as well as an excellent preparation for advanced work in the experimental sciences.

Next to actual sight of a thing is detailed explanation of a carefully outlined picture. So the stereopticon may supplement the work in a most interesting manner where direct contact with nature is impossible. Through this means the students may be given a trip through the Yosemite, a visit to Yellowstone, or taken to Greenland with its tracts of snow and ice.

The topics to be considered in a one year course in physical geography have thus far only been touched. Were the opportunity given me to choose, and then apportion the time accordingly, 10 weeks would be devoted to structural geology, 20 weeks to dynamic geology, and the remainder of the year to the atmosphere, its forces and its effects on the distribution of life, stealing just enough time for the mystery of astronomy to encourage a desire in the student to pursue it as a regular subject. But whatever the topics chosen, the aim should be, not knowledge, but the power to gain knowledge. Too long has physical geography been made a " knowledge of facts;" let it now become a " knowledge of things," with the sole object of inculcating habits of close observation, thus giving the student in his first high school year a key to unlock the gates of all the other sciences, and the ability and desire to be all his life a learner. Then only has the teacher obeyed the command of the poet,

Invite the eye to see and heart to feel
The beauty and the joy within their reach;
Home and home loves, and the beatitudes
Of Nature free to all.

### Discussion

**C. Ellsworth Call**—In our school we follow the lecture, recita- and laboratory method. The periods are 45 minutes each, and ee periods a week. All in the high school study physical geo- phy, no matter what course they take. This year we have about pupils in physical geography, taught by two teachers beside self. I instruct 185 in physical geography, four periods a day. e maximum number is 28 to a class. I have on one day, Thurs- y, five lectures, or five classes and four lectures; the other days ave four periods, some days recitations, some days astronomy, mathematical geography, or physical geography. One lecture fices to place the position of the earth in space clearly before the nds of the boys and girls, and some experiments with simple ap- ratus and specific gravity apparatus enable us to show the forma- n, or malformations of the earth. We then abandon that subject, quiz following the lecture. We immediately launch into the ings around us. We find that the atmosphere comes first. Its nstitution and characteristics are within the capability of the boys d girls. We have a chance to study the barometer; we have baro- raphs and aneroids. We attempt to get the observations of eather, etc. as a laboratory exercise. All the students receive from e beginning forms of coordinate paper, and are expected to ob- erve during the day or morning the barometer readings as given n the newspapers, together with the maximum and minimum hermal records, and they have become accustomed to convert the umbers into lines, making a useful laboratory exercise. Following hat, they take the weather charts as they come to us, and make hem the basis of translating. We find when we first give weather harts, they are but a mass of colors conveying no very definite deas. The translation of a weather chart is as difficult as the trans- ation of a map.

We begin the study of rocks immediately after the holidays. Our lan is about this. We take a sample of rock, like sandstone, ranite, quartzite, schist, and study its surface, the freshly broken urface as well as the weathered surface, getting some information of the effects of the atmosphere on the rocks. We shall attempt to find later on possibly the way whole areas of country are modified. We are fortunate in having the sea near us, within five miles, so we have studied the waves of the shore, their destructive action and their constructive action. As to tides, we have simply learned that there are such things as tides and currents, and we give no laboratory work. Volcanos are studied by models, and some idea of a volcanic mountain as distinguished from an ordinary uplift is obtained. The object of the entire course is to introduce the boy and girl to some of the common phenomena. We have nothing of the biologic side.

**R. H. Cornish** mentioned the need of simple problems and equipment in laboratory work, and the difficulty of having valuable field work in a large city.

**Sup't J. I. Gorton** declared the necessity of bringing out the influence of physical features on life, and gave his experience in the attempt to teach too much physical geography in elementary schools.

**Philip Emerson** spoke of the work done at Wellesley college by Elizabeth F. Fisher in bringing out the relations between physical geography and life.

No formal motions were passed by the earth science section, although the feeling was strong that the committee should be continued, and give its attention to relating the high school course to the elementary schools and to the colleges. There was practical accord touching the advisability of such a course as was recommended in the subcommittee's report.

## Section C. NATURE STUDY

### CHARLES B. SCOTT, OSWEGO STATE NORMAL SCHOOL

The chairman of the section arranged for the discussion of three topics: the aims in nature study; the material for study; the ways of helping teachers. Prin. George H. Walden was chosen to open the discussion with a paper, "The higher aims: to bring the child into sympathy with nature." Prin. Walden was prevented by sickness from being present. In his absence **Miss Alice Cynthia King** ened the discussion with a paper, "The subordinate aim: to aid other school work."

Mrs N. DeG. Doubleday ("Neltje Blanchan") had been selected present the claims of "Bird study" as one attractive and promisg phase of nature study. A misunderstanding as to the place of eting delayed her till near the close of the meeting, when it as too late for her paper to be read. It is included in the report proceedings of the meeting. Prof. J. H. Comstock presented the ims and value of "Insect study," Charles B. Scott discussed Plant study," and Prin. Anna J. Stone told of work in "Earth udy" which she and her pupils had carried on.

After an intermission for the examination of books and illustraons which had proven helpful in nature study and of nature study pers and drawings from the Oswego normal school and om schools in Syracuse and Utica, Prof. Wilbur S. Jackman condered the value of nature study as an end rather than a means, or ere aid in other school work.

As phases of the third part of the discussion on "Ways of helping achers," Dr Clifton F. Hodge spoke on the "Relation of teacher nd pupil in nature study," Mary F. Rogers told something about Nature study at the teachers institutes" and read, in the absence f the author, a paper on "Teachers leaflets and other work of e bureau of nature study" by John W. Spencer. Charles B. cott closed the discussion with a paper, "How the science teachers f the state can help teachers." The attendance at the section meetng was about one hundred.

Abstracts of the papers presented are given below.

### HIGHER AIM: TO BRING THE CHILD INTO SYMPATHY WITH NATURE

BY PRIN. GEORGE H. WALDEN, SCHOOL 10, ROCHESTER

Nature study, as it is rapidly coming to be understood, is such a combination of science and art that it offers a common field in which all teachers may work together.

When a young lad I was deeply impressed with the reply an Indian chief was said to have made to some public official who offered him a chair. "The earth is my mother," said this child of nature, "and I will recline on her bosom." This poetical expression of a most beautiful thought is the text of my plea for the higher aim of nature study. I do not believe that children are born scientists. This fallacy has had much to do with the wrong methods of nature study and nature teaching. Children are too emotional to be scientific, and too capricious to be thorough investigators. Like that forest child, they are poetic, highly imaginative; and when they have full liberty in favorable surroundings, they learn a great deal that is true in a way natural to them; but above all they learn to love nature.

In one who in childhood, had few companions of his own kind, and who, like Whittier's "barefoot boy," came directly under the tuition of Nature herself, the usual, dry nature teaching of our elementary schools touches no familiar or responsive chord. Such a one may not be, and probably is not a scientist. In his observations of nature he has few of the habits of mind peculiar to the naturalist; yet he is familiar with natural phenomena without inquiring too deeply into the causes, and what seems to me more essential, he has a love for nature—all nature—which scientific learning can not supply.

Is not this the higher aim of nature study? Does any one believe that science lessons will generally create this love, or that science will suffer if methods are resorted to which will cause all to love nature? If love of nature is our ultimate aim in the elementary schools, if we would have mother earth and all her children in loving embrace, we must give careful consideration to the methods of instruction. Method of nature study is not a part of my subject today; yet in discussing aim, I may properly note some principles which the framer of methods must take into account, if the ***higher aim*** is to be realized.

1 Introduce the subjects from the standpoint of the child instead of the teacher's. Here we find two very different view-points; yet the initial step, to be successful, must proceed from the child's interests. Let me illustrate from some subject which has been worked out more fully. Music and drawing have both had a history in this country somewhat similar to that which nature study is

ow going through. Till the higher general aim—love of music nd of art—became the guiding star of all elementary teaching, the ame problems had to be met that we are here trying to solve. The onditions are analogous. Does any one now contend that the aim f music and drawing in our elementary schools is to create *prima lonnas* and artists? Yet there are plenty of them; and so there vill be of naturalists, enough to do the world's work.

2 Study without a voluntary motive is not likely to lead to a ove of the subject. The study of Christian theology would hardly be expected to make men Christians, or of ethics to make men moral. The Christian worker knows that the souls he is trying to convert will make no response to any formal appeal to the intellect. The heart must first be reached. So with the teacher in nature work. If the heart is first right, the intellectual part becomes a mere matter of detail.

3 The teacher's soul must be as responsive to nature as she would have the hearts of her pupils to be. Without doubt, too little knowledge on the part of teachers is a great hindrance to their work; but I can conceive of too much unless the greater knowledge is accompanied by the greater love.

It remains for me to speak briefly of the importance of this higher aim of nature study. Love of nature tends almost universally to place us in harmony with our environment—it makes us free. It enriches life by increasing our capacity of love. Our love of man will be more embracing, and of God more intense. It becomes the foundation of all true art. It stimulates activity in science by arousing latent talent and thus it indirectly contributes to the material progress of mankind.

### VALUE OF NATURE STUDY AS A BASIS FOR OTHER SCHOOL WORK

BY PRIN. ALICE CYNTHIA KING, TEACHERS TRAINING SCHOOL, UTICA

We shall generally agree that nature study has a value to the child equal to that of any other school work in its power to ennoble character and impart happiness. Its higher aim would be sufficient reason for adding it to our school curriculum. But we find also that its value as an aid in other school work, if there were no higher aim, would make it worth while.

If a teacher arouses the interest of her children for 10 minutes each day in something good, she not only gains for herself and them the 10 minutes, but she gives the stimulus to other interest and attention all the day long. Nature study arouses that interest. With the possible exception of the story period, our children love the nature lesson best. Within the last two months several grades have written letters to me about their work, choosing their topics. Some wrote about number work, some history, but the great majority told what they were doing in nature lessons.

Besides gaining this interest, the children learn to see and think and write in an orderly, connected manner. In studying a plant they will observe and record all they can learn of the roots, the stem, the leaves, the blossoms and the fruit, each time observing all of one part before beginning another.

Through the use of the senses and interpretation of what is learned the child obtains material for the exercise of the reasoning powers—learns to ask " why " and to find for himself the answer—learns to say " because," thus rising to independence of thought and self-reliance. All these—interest, attention, systematic thinking, self-reliance—are direct aids in all school work. I will mention a few of the special studies which nature study aids, such only as I can illustrate concretely.

1 *Primary reading* can be based on the nature lesson of the day with excellent results. The nature lesson can be followed by a lesson in word recognition, after the children can *read* sentences from the board based on the morning lesson. The following may serve as a typical lesson. The children talked of the rabbit's food and manner of eating. Their reading lesson was from the board as follows:

I saw our rabbits eat.
The rabbits eat cabbage.
They like apples too.
Do you like apples?
I take apples with my hands.
The rabbit takes them with his mouth.
The rabbit lives in the woods.
In the woods they eat little leaves.

Such a lesson represents the children's observation and thought, d they do in reality gain thought from the written symbols. ten in connection with nature study some bit of good literature ıy be read or learned, e. g. the last stanza of Holmes's "Chambered utilus" when studying snails; or, in connection with bird study, ildren are delighted with this gem from Lowell:

> The little bird sits by his nest in the sun,
>     Atilt like a blossom among the leaves,
> And lets his illumined being o'errun
>     With the deluge of summer it receives.
> *He* sings to the wide world
>     And *she* to her nest.
> In the nice ear of Nature
>     Which song is the best?

Language is the expression of thought. The first requisite then ; *thought*. The advantage of nature work as a basis for language ; this, the thought in nature lessons is a result of the child's ex-›eriences, therefore is definite and *his own*. The value of nature tudy to geography is evident. Only through becoming acquainted vith the animals and plants in their own environment are children :nabled to imagine anything at a distance. Through the corn in :heir school yard gardens they comprehend the great corn fields of Iowa. In lessons on soil they see the decaying leaves, tree trunks, etc., which make the rich, fertile soil of the woods, and so understand one of the conditions of vegetable growth. Study of limestones, sandstones, of the wearing away of stones by water leads directly to a fuller comprehension of geography. Nature lessons are of value in other school work, but they seem to me most helpful in reading, language, geography. If we can through study of nature lead our children to do better work in these subjects—lead through interest to a happier attitude toward all school work—the result will repay the effort.

### BIRD STUDY

BY MRS N. DEG. DOUBLEDAY ("NELTJE BLANCHAN")

There are three points of view from which we may profitably look at bird study—that of the bird, of the teacher, and of the child. Let us briefly consider them with the order of their importance reversed.

Our grandfathers found this "a happy hunting ground" indeed, a sportsman's paradise. It was stipulated in contracts between apprentices and their masters in New England that the former should not be fed on heath hen—the eastern counterpart of the prairie chicken—oftener than twice a week, for the bird was disgustingly cheap because so abundant; but fewer than 50 of these luscious game birds survive today on the island of Marthas Vineyard. Its western prototype has already disappeared forever from several states where once every farmer's boy used it for a target. The wild turkey is fast approaching extinction. Every old sportsman can remember the flights of ducks that once came pouring out of the north in autumn like mighty rivers, actually darkening the country as they passed overhead. Exquisitely graceful terns, that constituted a volunteer beach cleaning and sanitary department, darted and skimmed off our coasts in enormous numbers, but women's hats and rubbish heaps contain most of their carcasses today—a pitiful remnant of the beautiful birds being at last protected by a paid keeper on an island off Massachusetts. Every one knows the tragic fate of the white egret that in certain regions once buried the verdure of the fields as if under heaps of snow. Who can possibly estimate the vast numbers of small song birds that have been stoned to death, or whose nests have been robbed by the small boy, or whose wings, if not their entire bodies, have been worn by the small boy's big sisters, cousins and aunts? Scarlet tanagers were once as abundant as robins in New York state. In Audubon's day flocks of wild pigeons estimated at several millions were a common sight; and so late as the centennial year one business firm captured over a million pigeons in nets spread over a single nesting colony, but because the Chicago market was so glutted with pigeons that it did not pay to transport them, many barrels of them were fed to hogs. Had bird study been introduced into the schools of the United States 50 years ago, these crimes against nature would never have been perpetrated. That they were committed indicates that we are still an undeveloped people. It rests with the rising generation whether our birds shall continue to decrease, or by protection reinforced by unstrained mercy, regain their lost numbers wherever possible. It is not possible for several of our choicest species.

Jnhappily I am not a teacher, and perhaps I do not see correctly m a teacher's point of view, but I imagine that a study which ı be relied on not only to interest a pupil, but to arouse him, to in his eyes to quick, accurate observations, his ears to catch the ıst delicate variations of sound, his mind to reach logical conclu- ns by reasoning as swift and often as subtle as Sherlock Holmes's; lead his attention into a healthful, stimulating, even inspiring ivity after school hours, makes a strong appeal to him. Let the ptical teacher who gives a lesson in complex fractions one period, bird study the next. Get out some pictures that show the birds their natural colors, if possible, a well mounted specimen or two, ssibly a nest or egg, a simply written, scientific yet entertaining d book, and some quotations from John Burroughs, Thoreau or e poets. Have a familiar talk with the children about the bird osen for study; note the long slender bill for extracting worms m the ground if it is a robin, or the blunt, heavy bill which the osbeak, cardinal and other seed-eaters use to crack the hard rnels. See if the boys and girls can judge from the shape of the rd's wing and body whether it travels by short passages or long, stained flights; or tell by its coloring whether to look for it among e foliage, as in the case of the greenish vireos, on the ground, in the case of the dusty sparrow tribe, high up in the trees where e tanagers and the orioles hope to keep their bright feathers out of arm's reach, or in the air at twilight when the dusky flycatchers e most actively engaged in their aerial sallies after winged insects. ager faces, rapid questions, a desire to tell of personal experiences nd observations of birds, and sighs of regret instead of relief when ne bell sounds and the class is dismissed, indicate more than ap- ears on the surface. Occasional trips with the class to the city ark or country woodland, with note books and pencils, help to ac- omplish results more speedily. Moreover they establish that bond f good fellowship and sympathy which is the basis of all successful eaching. It is only by training that a child observes quickly and xactly. He who notes the white feathers in the tail of the little rown bird flying across the road, correctly names the vesper spar- ow; or a peculiar waving flight, punctuated with ripples of song, knows the goldfinch; and he tells the oven-bird, one of the few walkers, by its pretty, mincing steps. A flower you may hold in your hand while you count its stamens under the magnifying glass and carry it home to your botany; but a bird is off like a flash sometimes, and one must make instant note of its peculiarities.

The normal child loves nature as Hiawatha loved it, as a savage, a brother and playfellow of every creature in the woods and fields. Generally he despises the city, longs for the country's freedom, and counts every moment lost spent within doors. Nature study satisfies one of his strongest instincts. It gives him the keenest pleasure—is what he is ever seeking while as yet he can not appreciate the training it affords. The migration of the humming-bird, an atom of feathers in the sky, from New England to Central America, can not but stir the imagination of the dullest child; the fidelity of the phoebe-bird that arrives at last year's nest a fortnight before his mate and welcomes her year after year with touching tenderness must appeal to the lover of romance; the devotion of the plovers to their dead and wounded comrades which they refuse to leave though shot rain around them, and all birds' nesting habits teach self-sacrifice; their means of obtaining food, their self-protection from enemies, make us marvel at their industry and cleverness; their beauty of color, form and motion appeals to the esthetic sense; and ethically they do much for children if they teach them only kindness. It has been said that birds can be successfully studied only with a shot gun. I have never killed a bird or taken an egg from a nest. One collection of stuffed birds or skins in any town is sufficient, and where museums are not accessible, patience, which more than any other virtue bird study teaches, always is. Had the last two generations of American girls been taught to know the birds, they could no more wear them on their heads than they could strangle their pet canaries. Had American boys learned the economic value not only of the game birds they helped to destroy or passively allowed to be killed in season and out of season by fair means and foul, but of the little weed-eating and insectivorous song birds, the wealth of the country would have been inestimably ter and the lot of the farmer particularly a far more prosperous . For many years the nations in the north of Europe gave llent protection to birds in summer only for the Italians to eat ng the winter migration. By stretching nets across the moun- passes through which flocks made their way, countless thou- ds of small birds were secured by the trappers. But insects an to multiply frightfully in Italy; so did weeds; her vineyards, hards and fields were on the verge of ruin by the pests when the ernment became aroused and took measures to stop bird slaugh-

It is estimated that the farmers of Pennsylvania lost $4,000,000 year through the ravages of field mice, because the killing of ls had been ignorantly encouraged by rewards the year before. ry many of our school boys become farmers, and of our girls mers' wives. As a nation we owe our chief prosperity to agricul- e. We make no apology for teaching botany in our schools. d study seems to this prejudiced observer to have even more ındant claims on our educators.

### MATERIALS FOR INSECT STUDY

BY PROF. J. H. COMSTOCK, CORNELL UNIVERSITY

In the following suggestions reference is made only to work with ung pupils, where the object is to awaken an interest, and develop ympathy with nature.

Nature may be observed from many different points of view; and who looks at her from only one will not achieve the largest ccess. The study of the activities, the study of the structure, and e study of the relationships of animals are not rival fields of labor, t parts of a harmonious whole, and all of these lines of study ould be opened to the pupil. But this is not the place for vague eneralities. The teachers who are beginning this work desire some ncrete suggestions as to available materials.

1 The necessary materials for the study of insect life are a few, ell-stocked aquaria and breeding cages. Do not buy expensive quaria and breeding cages, but use simple ones, such as the pupils an obtain for themselves. It is better to begin with aquaria, on

account of the greater amount of movement which goes on in an aquarium. Directions for making and stocking aquaria have been given in a Cornell bulletin, and elsewhere. With an aquarium a study can be made of the way aquatic insects get their air for breathing, how they obtain their food, how they provide for their young, and how they escape from their enemies; in a word how they live and get their living.

2 Materials for the study of structure should be obtained beforehand. Grasshoppers are more often used than other insects and as many writers have given directions for their study, perhaps they are the most available. With young pupils study only those parts which can be seen without dissection. Later study the structure of some of the insects whose habits are being observed, giving special attention to correlations of habits and structure. How and why the legs of a water beetle differ from those of a grasshopper, and other similar questions will be suggested.

3 Materials for the study of the relationships of insects will be easily obtained if the pupils are encouraged to make collections. But do not encourage your pupils to collect insects for the same end that they collect postage stamps, merely to have many kinds of something. Have the collections illustrate as fully as possible the life of a few insects. A knowledge of what an insect does is more important than the ability to distinguish two closely allied forms by counting the spots on their wings.

## PLANT STUDY

BY CHARLES B. SCOTT, OSWEGO STATE NORMAL SCHOOL

**Why study plants?** In the nature study in our elementary schools more attention has been given to plant study than to any other phase of nature study, for several reasons. In the first place, most people learn more or less unconsciously, much about the plants around them. To observe animals, such as birds and insects, requires more conscious or directed attention. Considerable plant lore is part of the general stock of knowledge of nearly all persons. Plants are more commonly kept or raised or cared for in our homes than animals. Therefore teachers are apt to emphasize plant study.

des, plant study, or botany, is pursued in our high schools more erally than the study of animals or minerals and the work in ny is not so likely to be limited to book study. Material for t study is, usually, most easily obtained, kept and studied. Ani- study, in the schools, often leads to cruelty, the result of ignor- : or carelessness. Finally, plant study correlates most easily naturally with much other school work, such as drawing and ature. There is much literature on plants, comparatively little nimals—except birds—and almost none on minerals.

/hile other phases of nature study are equally helpful and im- ant and will, it is hoped, gain a larger place in our schools, t study will, doubtless, occupy the leading place, or receive the t attention.

**/hat shall we take up in plant study?** The committee of : has recommended the following topics for preliminary or in- uctory work in plant study:

grades or years one to four.

ı fall. Formation, dissemination and protection of seeds

ı spring. Development of buds and germination of seeds

grades or years five to eight.

ree study in fall and spring

ome study of flowering plants.

hese topics were selected because they are simple and most :hers know or can easily observe much about them; because erial for their study is abundant even in large cities; and because / have a rich, esthetic content, are familiar subjects in literature bring out well the life and functional side of nature

**low study the topics recommended?** In all emphasize life development, lead the pupils constantly to ask and patiently to erve the "whys" and "hows," relate to literature, bringing out most elevating thoughts these phases of nature have inspired, l make the study helpful in other school work, by connecting h work in language, drawing and geography.

'or the study of germination, plant in the schoolroom early in ril early dwarf varieties of two or more kinds of seeds, such as bean, pea, morning glory, corn, pumpkin, and watch the development of roots, stems, leaves, flowers, fruit, continuing the study till the end of the school year. For the study of the root growth, plant some on damp blotting paper under glass.

For bud study, select in March two or three trees or shrubs, such as horse-chestnut, lilac, beech, elm, linden, poplar, currant, note the appearance of plant and buds before development begins, bring twigs into school in jars of water and watch there and outdoors the development of buds and growth of leaves, branches, flowers, fruit, continuing the observations till June. The development of the buds of house plants, such as begonia, and of weeds, such as yellow dock and buttercup, will reveal much about the devices of Mother Nature for protecting her plant children, the way in which the plant goes to work to beautify the world, and the final result in fruit or seeds. It is better to watch and record the development of three or four kinds of buds from March or April to June than to glance at isolated stages in the development of scores of buds.

For tree study, the elm, maple, beech, or evergreen is good. Observe carefully their winter condition, noting form, plan of branching, bark and buds. Keep record, with drawings or sketches, of development of each part, buds, twigs, leaves, flowers, fruit. Read or study related literature and history and impress esthetic value of trees to man. Bring out their utilitarian relations, the making of maple sugar and other uses of the maple, and the process of lumbering, with value of lumber, in connection with study of pine.

Continue the study of the same trees in the fall. Observe carefully their preparation for winter, the coloring and falling of the leaves and the growth and protection of the buds, impressing in the observational work and in the literature the thought of fall as a time, not of death, but of rest and preparation for a larger life. A careful observation of two kinds of trees from March to December will be much better than merely glancing at a score of trees or naming and carefully describing the mere structure or parts of a dozen.

## THE EARTH IN NATURE STUDY

### BY PRIN. ANNA J. STONE, BINGHAMTON

he term " nature study " as generally understood is a bugbear nany teachers. Instead of taking material with which children familiar, abundant at our very doors, they soar away to a dist clime for some rare plant or animal none of them has ever seen. boys and girls copy a few pages of flowery, high-sounding deption, and call it " nature study."

Vhether children live near the coast, in the mountains, or on the iries, the multiplication table, the parts of speech and the spelling k are related to the requirements of all. But to fit a course in ure work to all is an impossibility, and to misfits many discouragfailures might be attributed.

nother difficulty is in the amount of writing usually expected by ervisors. The pupil, instead of standing before his class and cribing in an intelligent, pleasing manner what he has seen, must ds write a story, profusely illustrated by drawings. Then the r teacher engages in her still hunt for errors. How successful is, none but the experienced know. The boy receives his corted paper, and writes and rewrites, even to the third and fourth eration, the things he hates. I do not wish to depreciate written rk, but to advocate more and better oral work.

Now for a bit of personal experience. In my school is a class of ft-overs," pupils who have repeatedly failed of promotion, and ve finally drifted together, an unpromising, dispirited lot. You y know such classes. They often exist even in the best concted schools. In the fall when work was assigned all the teachers oaned as fourth grade B was mentioned. I consented to be a rtyr three periods in the day. These children had made their le mud pies on the good, old sand board till their minds were as y as the sand in vacation. To them a hill was a chunk of dirt and ck sticking up in the air, and all that wasn't hill was valley. We came pretty well acquainted through a few days' study of the tures in our new geographies; then they were invited to bring mmers and join an excursion to a side-hill where a street was being cut through. We spent the time in breaking open the pebbles and noticing the difference between the fresh and weathered faces. This led to a series of lessons on weather and climate. Our second trip to the cut was to observe the rock layers, depth of soil, subsoil, comparative length of roots, the hight and slopes of the hill itself. Then we had the beautiful psalm, " I will lift up mine eyes unto the hills." This was followed by lessons on the action of heat, water, and frost on the rocks, the wearing away of the soil, change in surface, etc. After the hills came a study of the valleys, the meeting of the slopes at their lower edges, with the brooks winding down between.

In our yard is a small stream that joins the river a few rods away. Our first formal visit here was after a rain when the " crick was up." We did not try to find out why the stream was muddy. The pupils knew already from previous observations. Why is it teachers treat children as if they had no mind or judgment of their own? We talked about erosion, silt, velocity, current, right and left bank, course of stream, and its final destination. The boys wished a big Spanish warship would come up from Cuba, so they might have some fun. When the water subsided, we went out again and built a stone dam. This made an admirable lake with inlet and outlet. Along the bank were numerous peninsulas and islands, all firmly fastened at the bottom. In class we studied the Great lakes and several important islands, continental and oceanic. A neighbor felled a buttonball tree on the edge of our creek, and that night during a storm it floated down stream a hundred feet or more. We commenced lumbering at once and carried on that occupation in a most entertaining manner till all the lumber in the world was exhausted.

We began the study of air with a bicycle pump, then used a lamp to get a current of hot air, and finally floated out on the winds of heaven. During a sharp cold wave one of the boys told me the Eskimos were having a spell of warm weather. I asked him how that could be and he said that all the cold wind from the north pole was blowing toward the south and the hot air from the equator was rushing in to take its place.

That are some of the results of teaching about the earth, the home ian, in this manner? I dare not tell you what I *know* they will It will not make *all* the bad boys good, nor all the stupid girls ;ht. But what a power it bestows on them to see the works of wise Father in a new light, and read from Nature's book beauties een by the uninitiated! Shakspere must have had this power n he wrote:

> Tongues in trees, books in the running brooks,
> Sermons in stones and good in everything.

## THE RELATION OF TEACHER AND PUPIL IN NATURE STUDY

BY DR C. F. HODGE, CLARK UNIVERSITY

believe it is Prof. Scott who has given as a chief reason for inlucing nature study into our schools that it "trains teachers to :er methods of teaching." If I might be permitted to state the : a little more broadly, I should say that nature furnishes just the :erial necessary to bring teacher and pupil into natural, mutually ›ful relations. I feel deeply that in the unfair treatment of our :hers lies one of the gravest dangers which confront the nature ly movement. The point of unfairness consists in the charge, :n reiterated, that teachers do not know enough about nature to e instruction about it; and this is made with the insinuation that y should go to work to learn it as they do other things. For the :her to fill his head with nature lore and compel his pupils to n it, is the surest way to kill out all love of nature in both teacher l pupil. In demanding any such thing those in authority in ıcational circles are demanding a grievous impossibility, and reby defeating their own ends. A teacher would have to be a nbination of 10 specialists at least to answer one tenth of the quesns which a class of children will ask about the common forms of ure. In order to succeed nature study must remain largely, I am npted to say wholly, a matter of the heart and the will, of love for ure and the will to do all the good in the world possible. This is we should require of teachers of nature study in elementary and :n high schools; and when we require more, in the way of expert owledge, we are in grave danger of killing love of nature and thus of drying up all possibilities of scientific development at the fountain head.

My ideal relation between teacher and pupil can be illustrated in this way. The child brings some natural object to his teacher, possibly an insect. The teacher asks the child to tell all he has observed about it, what it was doing, where he found it, etc. If the teacher has never seen it before, so much the better, so long as he can take a real interest in it and leave in the child's mind the impression that it may be well worth learning something about. You all know what a delight it is to a child to tell a teacher something he does not know. The worst boy in the school will run his legs off to find something which will afford him the opportunity of doing this. Why not give pupils this delight oftener? The bane of our educational system lies in the idea that the teacher should know it all and that it is a disgrace to say "I don't know." Nature study rightly carried on can kill this old fallacy and thus leaven the whole lump, placing teacher and pupil in the natural relation of mutual helpfulness in the struggle and the pleasure of learning. "Thus," in the words of Fröbel, "father and son, teacher and pupil, parent and child, walk together in one great living universe;" and "not the communication of knowledge already in their possession is the task, but the calling forth of new knowledge."

### NATURE STUDY AT TEACHERS INSTITUTES

BY MISS MARY F. ROGERS, CORNELL UNIVERSITY

The teachers institutes of New York state are made up of the teachers of the village and district schools. Knowing so well the overcrowded condition of the school curriculum, I was prepared to encounter indifference and even antagonism when presenting the subject of nature study to the teachers. I was most agreeably surprised. Their attitude has been kindly and their interest most gratifying. Teachers are eager to begin the nature work, and will do it in the best way if they can find out that way. They have a hearty appreciation of all efforts to help them. Applications for teachers' leaflets are many, and the number from rural teachers is increasing. About one third of the teachers met at institutes send

heir names for the leaflets. This is very encouraging to those
o have the advancement of the nature study movement at heart.
t there are some obstacles in the path, which may not seem
ious to the scientist but which look insurmountable to the
chers of the elementary schools. The teachers themselves lack
t very love of nature which they wish to develop in their pupils.
iat knowledge and appreciation they have are too often second
id. Then, too, they are untrained in nature study, as to both
tter and method. It is easy for the trained scientist to say to
chers, "Study nature." But what can we expect of teachers
ose idea of study is always connected with a printed page? How
ı they help taking this view when even the botany and zoology of
ir high school days was a study of books and names? Their
orts at nature study have naturally been along these lines, and we
'e the study of leaf margins, naming the parts of the typical flower,
l the like technical science diluted to fit the grade the child has
ched in school.

The teachers feel their lack of preparation and are slow to under-
e much work. Some of them seem to think that in order to do
r kind of nature work one should know all science. "The
cher" has so long shared with the textbook the monopoly of
owledge that any other conception of the teacher's position is
'd to establish. The teacher a student with her pupils is a notion
t is growing, and the success of the nature study movement de-
ıds largely on the rapidity and strength of that growth.

At the institutes during the last two years an effort has been made
introduce real nature study; doing with teachers the kind of work
y would do with pupils if they knew how; helping teachers to a
v point of view toward nature itself and the study of it. This has
n accomplished largely by means of lessons on common things—
ngs so easy to get and apparently so uninteresting as to be un-
rthy of notice. Teachers are urged first of all to become students
nature with their pupils, to lead children to an appreciation of
ure and a love for it by indirect rather than by direct means, and
make an effort to rid their minds of the superstitious fear of
ure, so aptly described by a teacher of city children when she said

that her pupils felt that all nature was " layin' fer ye," and one of the commonest questions asked her was, " Teacher, what does them do to ye? " What a pitiful state of things, and not confined to the city!

I am sure that the science teachers of the state can do much to help the teachers of the elementary schools do the right kind of nature work. If there could be more study of things and of life in science courses in high schools, academies and normal schools, to say nothing of the colleges, we should soon begin to feel the effects of it in the lower schools, even to the lowliest of all, the neglected country school.

### THE WORK OF THE BUREAU OF NATURE STUDY

BY JOHN W. SPENCER, COLLEGE OF AGRICULTURE, ITHACA, N. Y.

The primary object of leaflets in nature study was to equip the teacher in the rural school to become an investigator, with her pupils, of some of the common things found in country life; for it should be known that the Bureau of nature study is part of a movement for university extension of agricultural knowledge, provided for by an appropriation made by the state of New York, to be administered by the College of agriculture of Cornell university.

This extension work has two divisions—one investigative, taking investigation to the farm of the farmer and assisting him in solving some problem peculiar to his vicinity. The other division is educative. The first step taken in this latter division was in holding itinerant schools in which the why of farm operations was taught more than the how. The next step was the formation of a farmers' reading course on the correspondence or Chautauqua plan. The third step was to do something for the farmers' children that they might be led to see some of the interesting things about them, by trained observation be better qualified for agricultural pursuits, and rural life be changed from one of monotony to one of lively interest.

A few leaflets, as feelers, were issued during the school year of 1896-97. It was not till the school year of 1897-98 that we felt prepared to push our method into the common schools with much force. During the first year the leaflets were very cordially received by the grade of schools having superintendents. At the beginning of the esent school year of 1898-99, the demand has come almost exusively from the small towns, villages, hamlets, and, in some cases, om the rural schools. Ending with Dec. 31, requests for leaflets om those places have come in at about the rate of 1000 names a onth. The total number of teachers' names on our mailing list is out 22,000, all placed there by written request. We have pubshed 11 leaflets and shall probably increase the number to 16 or 17 y or before the coming spring. It is one thing to provide literature n nature study, and another to induce teachers to take it up. Vhen one considers that it is a comparatively short time since the nterprise was launched and that a multitude of teachers were unrepared for it, the amount of good work done is satisfactory.

We have always urged teachers, as a first step, not to let nature tudy occupy a period in the school work, but rather to have some amiliar object, such as the young squash plant, the tent caterpillar, he pollywog or other denizen of an aquarium, placed where it can be reely observed by the pupils, and require them to make what they iave seen the theme for their language and drawing periods. It is iow our design to induce teachers to send such compositions and drawings to us and receive similar work from the children of other schools. We find that the contrast between the surroundings of city and country schools gives more interest to exchange of work than would be created if the exchange were made between schools of cities or between schools of the country. We count every teacher a friend who assists in the promotion of this exchange of correspondence.

We do all we can to promote a study of the thing itself rather than the study of books with a recitation to follow. Some teachers fancy they can teach nature study by exalting the pupil's understanding to such an altitude that the teacher can give science as she has learned it. Those in the bondage of book slavery would better let nature study alone.

### HOW SCIENCE TEACHERS CAN HELP OTHER TEACHERS

BY CHARLES B. SCOTT, OSWEGO STATE NORMAL SCHOOL

In closing the discussion Mr Scott dwelt on the fact that the education of the past has been largely an education of books and has not trained the student to observe. Few of our teachers know how to observe and hence they feel handicapped in work, the essence of which is individual observation. However earnest they may be, however willing, they feel like blind leaders. Perhaps this feeling is intensified by the consciousness that those they lead are usually not as blind as the teachers. The children, particularly in the primary grades, have not so far lost the power of seeing, with which nature endowed them.

Teachers need help and guidance in studying nature, not mere lectures or talks but observational work indoors and out in the streets and fields. Science teachers in high schools or academies, or principals and teachers in the elementary schools, having scientific interests and some training in observation, are the ones who can best help other teachers. They are best fitted to give help because of scientific training and experience as teachers. They are on the ground, in contact with the elementary teachers, most familiar with their needs and capacities. If nature study is to be widely and successfully introduced, it must be through teachers classes, meeting weekly, at least during spring and fall, studying the material which the children in the schools are to study, with occasional field lessons and, when possible, talks, illustrated with stereopticon slides, on such topics as trees, birds, or insects. Mr Scott touched on his own experience in conducting such volunteer classes for the teachers of St Paul, Minn. They were the principal means of introducing nature teaching and engaging in more or less definite systematic nature study 10,000 to 12,000 children in the St Paul schools.

The thought was emphasized that science teachers who did such teaching would find themselves and their high school work greatly benefited. The high school and elementary school would be brought into closer relations, the pupils would come to the high school with greatly increased interest in nature and increased power to see, think and utter, and, perhaps best of all, the science teacher, working with the teachers of children and planning work for children, would be led to think of his pupils more and less exclusively of his subjects, thus becoming more a teacher of real science.

## Section D. PHYSICS AND CHEMISTRY

### CORRELATION OF SCIENCE WORK IN THE HIGH SCHOOL AND COLLEGE

BY PROF. WILLIAM HALLOCK, COLUMBIA UNIVERSITY

I have the pleasure of standing for this little list of experiments prepared by the subcommittee of nine; and it is modest of Prof. Arey, having had so much to do with the preparation of it, to let me present it. He is to be congratulated on the program he has prepared, because it appears to promise a good discussion. One of the experiments that we put down on the list as a separate experiment is very often combined with others—that is, plotting the curve. After I had seen Prof. Arey's little program and during most of the discussion as to the proper method of presenting zoology in the secondary school, I tried to plot the curve of the program. I thought in the first place it was ascending, for it started with a zero all right. I tried various solutions. I tried the semiparabola. That started with zero, but it got Prof. Hall and Prof. Nichols only part way up, so that I finally had to admit that in one case I could not perform one of the experiments that I had put in the list.

Contrary to usual custom with me, I have written out a few points that I wish to dwell on, chiefly in order to put myself on record; and if I utter any rank heresy, you can ascribe that to me as an individual. If on the contrary any good ideas be presented, it is due to my association with this subcommittee more or less for two years. The accompanying list was prepared by the subcommittee to serve as suggestions. Let me apologize to the scientific public of the state because, in preparing this for the press, I did not state that fact on the list anywhere, an omission which would naturally lead any one to suppose that the school was expected to go over the whole list. It was not expected that even the best class in the best schools would be able to cover the entire list in a year of five periods a week.

The committee has felt that the first step is to settle on the matter to be taught. When the list reaches its final form, it is the committee's intention to amplify the description of each experiment, so that the teacher may see exactly its object and receive suggestions for the performance of it. Then will follow references to all the laboratory manuals available which give some form of the experiment under consideration. Possibly it may be desirable to supplement this bibliography with a corresponding list of apparatus. By referring to all textbooks and instrument makers it might be possible to avoid personalities. So much by way of explanation. The list was primarily designed for the 99% of high school students who do not enter college. For them a course should be provided wide enough to give an insight into the great subdivisions of the science, yet solid enough to give them an appreciation of its definiteness and quantitative accuracy. In physical laboratory work the idea of quantity, of measurement is first thoroughly developed. Chemistry has not, nor has mathematics, the same value for quantitative work. The one deals almost entirely with ratios, or masses, the latter with lines, which give area and volume. I refer to the twofold value of physical laboratory work, for subject-matter and experience in quantitative work, while pointing out that we have endeavored to bear both in mind in the choice of experiments. Fortunately most experiments give prominence to both.

We have been assured that certain of the experiments should be left to the college. Not if they have real value and are otherwise available under high school instruction and equipment. Our first object is to give the students who do not go to college the best possible course in the time allowed. Then it will follow as the night the day that this course will be found to fulfil the entrance requirements of those enlightened colleges which accept preparation in science.

There are, no doubt, college professors who can not endure the thought of their dear science being murdered in the high school, and prefer to have students enter without any knowledge of their special subject. But shall we professors of science in colleges sit down and say that we can not coordinate college work with the honest instruction which the preparatory schools may be able to give, though the professors of Greek, Latin and mathematics have always done it? How would the proposition be received if a professor of mathematics asked to have the entrance requirement in athematics abolished in order that he might teach his students the ultiplication table according to his own approved method? We ust, rather, help the secondary schools to do correct work and en coordinate our college work with it.

Certain points may surprise a reader of the list, i. e. the few exriments in sound proper. Sound offers few good quantitative exriments available for a number of students at once. Expensive paratus and interfering noises are some of the rocks on which its aves break.

Static electricity is better in the lecture-room than in the laborary. It is too uncertain and fitful for the laboratory. Weather nditions will often obliterate and sometimes reverse the point at hich the experiment is aimed. There are many attractive experiments that are not on the list. Most of them may well be left to the eal of the instructor and students. The list experiments are innded to point a principle or a phenomenon rather than to amuse r simply interest. In the latter line no science teacher could begin o compete with a mediocre prestidigitator. Any physical experiment if properly presented will interest, while it instructs the great ajority of students.

Certain experiments have met decided opposition; for example, ogarithmic decrement. Yet I feel that logarithmic decrement is no ugaboo, and if it had been called " rate of dying down of a pendulum " or balance, it would have escaped criticism. Aside from eaching the pupil the way a pendulum would die down if the spring f the clock were not active, it teaches him quantitative work " on ime." He must read, and make up his mind quickly. It is easy to do many things very accurately if we have time enough, but it is quite different if they must be done in a small fraction of a second. If we suddenly find ourselves between conflicting trolley cars and wagons, we must estimate distances and velocities quickly if we are to come out with a whole skin. That is no place for a slow, detailed computation. Incidentally a pin, a stone, a foot rule and a piece of thread are all that are necessary to determine logarithmic decrement.

It may interest the section to know that I sent upward of 200 copies of the list to the principals of practically all the high schools, academies, seminaries, etc. in the state. Apparently more were consigned to the waste paper basket than were returned to me, though I fondly hoped that we should receive much valuable criticism.

Inasmuch as we have culled the various experiments from all possible sources, we owe a large debt to those sources, though in consequence we can not say of the list as Touchstone did of Audrey, " An ill-favored thing, sir, but mine own."

[Prof. Hallock then presented the list printed on p. 520-26.]

## A STORY OF EXPERIENCE WITH PHYSICS AS A REQUIREMENT FOR ADMISSION TO COLLEGE, WITH CERTAIN PROPOSITIONS

BY PROF. EDWIN H. HALL, HARVARD UNIVERSITY

I have been asked by Mr Arey to write a brief paper giving my " experience with students offering experimental physics as an entrance requirement" for college and my "conclusions concerning the relative disciplinary values of experimental and textbook physics in secondary schools."

My experience with physics as a requirement for admission to college dates from September 1881, when I began my connection with Harvard college by making out a set of questions to be used in the impending examination of candidates for the freshman class. For several years before and after this the examinations were on the basis of textbook work only, and they were entirely written. They had acquired, before I had any responsibility for them, the reputation of being ridiculously easy to pass by cramming, and I have no doubt they deserved it. From the character of the papers and from the statements of the examiners it is plain that the work of examination was conducted on the side of the college in a perfunctory way. I felt at first little enthusiasm for the task, and can remember rejecting and almost resenting the suggestion of a colleague that I should undertake seriously the labor of improving the teaching of physics in schools. It fell to my lot, however, to set all the examination papers in physics and to read all of the candidates' answer papers, or " books," for several years. I did this work conscientiously if not gladly, and believe that the textbook quirement lost by degrees something of its undesirable reputation; it after some years, this requirement still being unsatisfactory, a rtain amount of textbook astronomy was added to it, and at the me time an alternative for this combined textbook study was fered in the shape of a laboratory course in physics. Simulneously a course in chemistry preparatory to college was outlined id established under the special care of the late Prof. Cooke, at at time head of the department of chemistry at Harvard. To m and to Pres. Eliot, who had been a teacher of chemistry, is obably due most of the credit of committing the college to the cperiment of these laboratory courses. To them was due also, suspect, the mistake of projecting the physics course on precisely ie same lines as the chemistry course. Each was defined as the erformance of a number of experiments with "lectures or other al explanations in addition to the descriptions given in the laboraory manuals." In each the candidate was "required to pass both a ritten and a laboratory examination," the written examination directed to testing the candidate's knowledge of experiments and kperimenting as well as his knowledge of the principles and re- ılts" of the science, the laboratory examination "directed to testıg his skill in experimenting." In short, the emphasis was all on kperiments and experimenting, as it should be perhaps in chemisy, but as it should not be in physics. However it may be with ie chemist, the physicist must have time to chew the cud. To gnore this, as those did who framed in general terms the original Iarvard requirement in elementary experimental physics, is to ıake a serious mistake. There were other mistakes for which I ıust bear the main responsibility; crudeness of apparatus at which now shudder, though we have not attained or aimed at any reat precision of measurement, laying out the "method of disovery" farther than the student could follow it, restricting too nuch the range of options in experiments. In spite of these misakes and others, and in spite of the difficulty met by teachers in inding money and time for laboratory exercises, the experimental ourse was successful from the start. It took root and it grew.

The teachers of physics welcomed it; they found themselves learning physics more rapidly or more thoroughly than they had ever done before, and therefore teaching it more zealously; they found themselves growing to be a recognized and respected class in their profession, as they had not been before. The proportion of candidates offering experimental physics, instead of the textbook alternative, increased rapidly till in a few years it became more than 70% of all. Meanwhile the intelligence and proficiency shown by the candidates in their laboratory examination grew from year to year till it became a source of much gratification to the examiners, who felt that young men were coming to us with a knowledge of physics wide enough and sound enough to justify us in taking account of it in shaping our courses of instruction in college.

But now came a reaction. The first impulse was spent; the novelty, for the teacher, was gone; the faults of the experimental requirement, in general features and in detail, became more and more obvious and vexatious. An association of New England teachers of physics was formed, which spent much of its energy in criticizing the Harvard preparatory course. There were good reasons for dissatisfaction and this dissatisfaction was pronounced. From the admission examinations of 1893 to those of 1897 the number of candidates offering experimental physics fell rather steadily from 358 to 312, while the proportion offering experimental physics instead of the alternative work fell from 72% of all to 55% of all. Many changes of detail had been made from time to time with the object of satisfying the complaints or criticisms of teachers, but something more radical was needed. At length the Harvard faculty got around once more to the revision of admission requirements; and, on representations made by the department of physics, it said to that department, "Make your experimental course what you think it ought to be." Accordingly, a new statement of the plan and objects of that course was made, and the exercises suggested for the use of candidates following it were thoroughly revised. The new statement and new descriptive list of experiments were published in the summer or ly fall of 1897. What was the result? The proportion of canlates offering the experimental alternative in physics rose from % in 1897 to 75% in 1898, the absolute number rising from 312 to 5. The tide has turned. Of course, if the present alternatives continued long, it may turn again. I do not prophesy; I merely re the figures to this date.

But I hope that the present alternatives will not continue long. e have in the recent revision of the experimental course made rather less a laboratory course and rather more a textbook, or ture, or recitation course than it has been up to this time; and ving done this we ask to have the textbook course pure and nple abolished. It is my belief, and I think it is the belief of ery member of the department of physics at Harvard, that a textok course illustrated by lecture table experiments can be made ry profitable to pupils of the high school age. But we hold that judiciously conducted mixed course, part laboratory work and rt textbook work, can be made far more profitable. Things never ok exactly as they are described, and they never feel exactly as ey look. To appreciate the merits of those who have extended ientific knowledge, one should know from experience how rigorusly the real kernel of truth is hidden from the careless or the npersistent. It is one thing to eat the meat of the nut; it is quite different thing to recognize it in the burr and crack it from the ell. The very difficulties and failures of experimental work are themselves highly instructive. The impatient pupil says, "This ing doesn't work right." My child, things always work precisely s they should; but they require us to do the same.

A pure textbook course, then, is at its best, far inferior to a ourse with laboratory work, at its best. Moreover, the latter kind of ourse is more likely to be well taught than the former. Textbook ork can be crammed, and any subject which can be crammed, ill be crammed, at least in schools which make much of getting oys into college. I believe, then, that your association will do a reat public service if it succeeds in establishing in the high schools f this state courses of science including laboratory work. There is, as I have just shown, a possibility of going too far in this direction; but this possibility is no doubt a vanishing quantity for the public school system of any state. There is another possibility of mistake, the possibility that a system instituted by state authority will require the performance of strictly prescribed work, nothing more and nothing less than some specific list of exercises. It is necessary for the best results that the teacher have a certain freedom of choice in his work. No good and experienced teacher likes to be or ought to be told exactly what he is to do. We have been led by experience at Harvard to give in the field of laboratory examination a set of exercises much more extensive than that which any one candidate is expected to go through in his preparation. In conclusion I will state certain propositions which I, as chairman of a committee acting in connection with a department of the National educational association, have made to the other members of the committee, in regard to physics in schools which prepare boys for college. These propositions are as follows:

1 That in public high schools and schools preparatory for college, physics be taught in a course occupying not less than one year of daily exercises, more than this amount of time to be taken for the work if it is begun earlier than the next to the last year of the school course.

2 That this course of physics include a large amount of individual laboratory work, mainly quantitative, done by the pupil under the careful direction of a competent instructor and recorded by the pupil in a note book.

3 That such laboratory work, including the keeping of the note book and the working out of results from laboratory observations, occupy approximately [not more than] one half of the whole time given to physics by the pupil.

4 That the course include also instruction by textbook and lecture, with qualitative experiments by the instructor, elucidating and enforcing the laboratory work or dealing with matters not touched on in that work, to the end that the pupil may gain not merely

pirical knowledge but, so far as this may be practicable, a com-
hensive and connected view of the most important facts and
vs in elementary physics.

5 That college admission requirements be so framed that a pupil
o has successfully followed out such a course of physics as that
re described, may offer it toward satisfying such requirements.
he question whether the college should hold an examination to
termine the candidate's attainments in physics is not here con-
lered.)

The committee consists of nine members besides myself, and all
t two have now expressed an opinion on these propositions. I
hall try to give these opinions in the order in which I received
em. Prof. Carhart of Ann Arbor subscribed to the propositions
I had given them. Prof. Nichols of Cornell subscribed to them,
ith the suggestion, however, that for the words "not more than
ne half" in the original third proposition the words "approxi-
ately half" be substituted. E. D. Pierce of the Hotchkiss school,
akeville, Ct., subscribed without change. Julius Hortvet of
he East high school in Minneapolis subscribed after chang-
ng "not more than one half" in the third proposition to "at least
ne half." Prof. Sanford of Stanford university subscribed after
hanging "not more than one half" to "at least three fourths."
rof. Thomas of Columbus subscribed without change. Mr Ling
f the Manual training high school in Denver subscribed after mak-
ng a slight change in the first proposition. I believe therefore,
hat if we adopt the suggestion of Prof. Nichols and insert "ap-
roximately half" in the third proposition, we shall come very near
the average opinion of the committee as to the best division of the
time between textbook work with its accessories and laboratory
work with its accessories. As to the other propositions, the committee appears to be practically unanimous, so far as its members have expressed their opinions. I doubt whether anything more definite can be expected from this committee or any committee so widely representative as this. The propositions are, I hope, definite enough and well enough supported to be worthy of your consideration.

## Discussion

**Prof. Edward L. Nichols**—It seems to be a peculiarity of this discussion that we are all on one side. So far as the consideration of the question has gone among college men and teachers—and the subject has been maturely considered—there seems to be but one opinion, which is, I believe, well expressed by the various committees. The conclusions reached by the committee represented by Prof. Hallock, and the conclusions reached by the committee represented by Prof. Hall, come to the same thing. Both committees report that there is every reason to encourage laboratory work in the secondary school; that there is every reason when this work is done to give it a place in the entrance requirements for college; that it would be a mistake to confine secondary school work in physics simply to laboratory instruction; that it would be a still worse mistake to confine it strictly to learning the text; that so far as it is possible to express the relations between these two parts of the work, it ought to be about equally divided between the two.

Now as regards the question of putting out a list of problems. I confess to a certain degree of shrinking from that proposition, though I admit that it is the nearest way of indicating the sort of thing which we all agree ought to be done and of setting a certain standard. My shrinking from it comes from the feeling which the last speaker has expressed, that the teacher ought to have some responsibility and that his individuality ought not to be sacrificed in any way. One who is dealing with classes of students in a subject like physics ought to be continually striving for new methods of bringing out the things which he wishes to attain, just as every one dealing with literature must continually be striving for new means of expressing what he wants to say. Therefore, while this list is a good thing, and necessary at just this stage of our advancement, it ought not to be too rigidly insisted on. Experiments not on the list but which meet certain local conditions best ought to be cheerfully accepted. It is impracticable to add to the list of experiments till we have included in it everything that anyone who ever taught physics found to be good.

ke for example the training in estimation of tenths. We a variety of methods in which the estimation of tenths is made iar to the student. You can train the ear and the brain to together in a way which I have never seen described in any ook. I have tried it with gratifying results in the case of immature and untrained classes. The experiment consists in g up a seconds pendulum in circuit with a telegraph sounder Morse recorder. By means of a key in multiple circuit with endulum, time signals are made at random by the instructor. class, with note books in hand, estimate tenths by ear from earest seconds signals to each signal from the key. The work st is puzzling on account of the novelty of the exercise, but very short time the members of the class begin to be able to the intervals and to note them down. One should continue xercise for 15 to 20 minutes and then work out the re- by having some pupil read the records of the Morse recorder. members of the class compare the record with the list of time vals in their note books and make out a table of errors.

nention this to illustrate the fact that there are methods not in our list, which are of the greatest use in the school room in the sense of observation. Every teacher will have occasion vise experiments that will enable him to use the apparatus at nand and will employ methods not on the list, and I think vork ought to be recognized whenever it is good. So I would iasize what Prof. Hall has said, that the teacher ought to be vn on his own resources in these matters and not tied down y list of experiments. At the same time such a list serves a useful function in indicating what constitutes valuable labora- practice, in contra-distinction to much which in various quar- in the past has been dubbed laboratory work in physics.

ow as regards the engineer. The entrance requirements for g engineers ought of course, so far as science and mathematics be somewhat more rigorous than those for the general student. uld like to protest against assertions to the effect that imper- raining in science is positively harmful. Is it fair to the intel- ce of the students in our schools to imagine that poor teaching of physics really indoctrinates those students into a belief in the things that are not so? The inquiries which college students are continually making show that they have rarely been deceived by inaccurate statements and that they do a good deal of thinking for themselves. I am not saying that it is of no consequence whether we teach the things that are so or those that are not, but I do mean that as between a class that has never had any physics and one that has been poorly taught the latter is to be preferred. It has been my experience that such preliminary training in the schools plants the desire to go into the subject thoroughly and from the beginning once more. My experience is that those in a class who have had the longest acquaintance with physics are the most likely pupils and that from them the best results are obtained. There is something about experimental physics in particular, even the simplest experiment, of which one does not tire. To go into a lecture room where some one is demonstrating and watch the phenomena, no matter how familiar, is always a new delight to me, and this I think is no individual peculiarity.

We must teach the beginner in science in such a way as to train the powers of observation and develop the power of thinking. In the case of engineers, who are going to do throughout their university course practical work in the applications of physics, the more physics they get in the high schools the better, and the more laboratory practice they get, without neglecting that which must go with it, the better. Therefore I am in favor of putting physics down in all engineering courses as an entrance subject for college. At the same time I think that the most serviceable thing is to continue to teach the elements of the subject in the engineering school or university. As I have just pointed out, no lack of interest is to be feared from such review, provided the treatment in the university is, as of course it should be, more thorough and fundamental than that in the secondary school. The pace which can be set with the class in consequence of previous training will be such as entirely to compensate for the time thus spent, so that, while there might seem to be repetition in the beginning, it will not be mere repetition in the end nor waste of time.

.et us teach physics by laboratory methods to all pupils in the h school, whether they are to go to college or not; for engineer- students, the more time given to it the better. Let us classify students whenever possible and put by themselves those who are ning for the engineering schools. They can then be taught re thoroughly than the great mass, certainly much more thor- ghly than the average of those who are going into our general irses. That in most cases is impracticable, but physics, how- r taught, will do no harm to the young engineer and the earlier begins to think about such things the better. When he comes ) the engineering school he should have had physics straight ough from first to last; of course in the later years more and re of the applied work, but in the earlier years that fundamental rk which will enable him to make his own applications. We ght not to teach the trades to engineers. I earnestly believe that most serviceable thing that can be done for engineers in col- e is to teach them the things which they will not be able to get themselves when they go out into the greater world. The man o is thoroughly grounded in his mathematics, physics and chemis- is potentially an engineer, and when he goes into the field or workshop, given the manual training which should supplement entific study in all engineering courses, he is in position to apply nself to any problem that may confront him. Engineering iools, then, ought to recognize physics as an important portion their entrance subjects. Teachers of physics in the schools ght to know that wherever their work is well done it will find :ognition on the part of those who have to take up their material d work with it later on.

One of the chief objects of this association is to secure an ade- ate portion of time and an adequate equipment in the schools d to secure by individual effort that knowledge of the subject iich will enable us to teach it as it ought to be taught. When ese things are done, one portion of our task will be entirely ac- mplished. There will then remain but one subject for this asso- ıtion to discuss, which I trust we shall still be enthusiastic enough meet once a year to consider, that of science itself. I look forward to the time when the science teachers of the state of New York will get together to talk science; when all these pedagogical questions which are now troubling us and which we are striving to solve will have solved themselves through the work of our various committees and in the ways which I have just attempted to outline. Science in the schools will still need this association for the development of individuality, originality and enthusiasm. Scientific work needs these characteristics just as much as literature. It can not be machine made any more than poetry can. The Science teachers association in the new era of which I speak will be a teachers science association, and its prime function will be to stimulate and keep alive the scientific enthusiasm and fruitfulness of its members.

## PROPOSED COURSE OF PHYSICS FOR THE SECOND YEAR OF THE GENERAL AND COMMERCIAL COURSES IN THE HIGH SCHOOLS OF MANHATTAN AND BRONX BOROUGHS, NEW YORK CITY

BY PROF. FRANK ROLLINS, BOYS HIGH SCHOOL, NEW YORK CITY

The specific subject on which I am expected to speak accidentally came to my attention late last evening, but it has been my good fortune for once in my life to be forearmed without being forewarned. It has happened during the last year that the two colleges which are a part of the public educational system of the city of New York have requested from the new high schools in the boroughs of Manhattan and the Bronx a statement as to the work in physics that they would undertake to do with pupils in preparation for college, not necessarily work preparing for the normal or city college, but general college preparatory work; and it fell to my lot to prepare this statement in conjunction with my colleagues—who have contributed much of whatever balance or symmetry it may possess—and to put the official report in shape and forward it to these colleges. It happened to be precisely what you have called for in the program and I can not do better, I think, than simply and briefly to state what we will undertake to do.

Exercise 1 Proper use of instruments in weighing and measuring, illustrated by determining the density of a rectangular block of wood.

Sources of error *a*) in instruments, *b*) in observer, *c*) in material l be discussed here; and methods of eliminating such errors will considered.

A method of detecting the limit of significance in the figures of e numerical results will be thoroughly explained by the teacher, d practised by the pupil in connection with this exercise, and will considered in connection with each succeeding quantitative ex- cise.

Exercise 2 *a*) Principle of Archimedes, *b*) weight of 1 cc of ter, *c*) specific gravity of a floating body.

Exercise 3 Specific gravity of a light body by use of a sinker.

Exercise 4 Specific gravity of a heavy body.

Exercise 5 Specific gravity of a liquid: *a*) by specific gravity ttle, *b*) by buoyant effect compared with the buoyancy of water, by balancing columns in a U-tube, *d*) by balancing columns sup- rted by atmospheric pressure in an inverted U-tube.

Exercise 6 Specific gravity of air.

Exercise 7 (Lecture-table demonstration) Laws of pressure in quids.

Exercise 8 (Lecture-table) Atmospheric pressure as measured y the barometer, and as applied in the siphon, the lifting-pump, e force-pump, and the air-pump.

Exercise 9 (Lecture-table) Boyle's law.

Exercise 10 Tenacity of brass as calculated from the breaking tress of a brass wire.

Exercise 11 (Lecture-table) Illustrations of mass, inertia, and orce.

Exercise 12 Laws of equilibrium of parallel forces acting in ne plane.

Exercise 13 Laws of moments of forces.

Exercise 14 Laws of concurrent forces in one plane. Result- nt, equilibrant, parallelogram of forces, triangle of forces, composi- ion and resolution of forces.

Exercise 15 (Lecture-table) Center of gravity. Center of gravity and stability. Center of gravity of a lever.

Exercise 16 Laws of work by the inclined plane, forces being used in three directions.

Exercise 17 (Lecture-table) Machines: wheel and axle, wedge, windlass and pulley.

Exercise 18 (Lecture) Laws of falling bodies.

Exercise 19 (Lecture) Energy: potential, kinetic, conservation of.

### HEAT

Exercise 20 Testing a mercury thermometer. Influence of pressure on the temperature of steam.

Exercise 21 Coefficient of linear expansion of a metal.

Exercise 22 Coefficient of cubical expansion of air. Absolute zero.

Exercise 23 (Lecture) Conduction, convection and radiation.

Exercise 24 Effect of mixing equal masses of water at different temperatures. The heat unit.

Exercise 25 (Lecture-table) Effect of mixing known masses of water and of a metal at different temperatures. Specific heat.

Exercise 26 The dew-point. Phenomena of boiling. The steam-engine.

Exercise 27 Temperature of water at its greatest density.

### SOUND

Exercise 28 Laws of the pendulum.

Exercise 29 The vibration rate of a tuning-fork.

Exercise 30 Velocity of sound in air, by length of resonant tube.

### LIGHT

Exercise 31 Relation between intensity of illumination and distance from source of light.

Exercise 32 Candle-power of a lamp.

Exercise 33 Law of reflection, size and position of images of reflection in a plane mirror.

Exercise 34 Path of a ray of light through a glass prism. Index of refraction.

Exercise 35 Focal length of a double convex lens.

xercise 36 Conjugate foci and relation between conjugate
l distances and the focal length of a lens.

xercise 37 Lectures, demonstrations and quizzes on the ap-
tions of the lens in spectacles, microscopes, telescopes, cameras
stereopticons.

### MAGNETISM AND ELECTRICITY

xercise 38 Lecture on law of magnets.

xercise 39 Forms of lines of force about a magnet *a*) with
h-seeking end pointing north, *b*) with north-seeking end point-
south.

xercise 40 Lecture on static electricity.

xercise 41 Study of the simplest voltaic cell with reference to
uit, conductors, nonconductors, positive plates, negative plates,
s and direction of current.

xercise 42 Direction of the current as related to a compass
dle near the conductor.

xercise 43 Lines of magnetic force about the field of a tangent
vanometer.

xercise 44 Comparison of a simple cell with a two-fluid cell
espect to constancy of current. Polarization.

xercise 45 Effects of electro-chemical action on the weights
the plates of a cell. The ampere.

xercise 46 Effect of length and diameter on the resistance of
onducting wire.

Exercise 47 Effect of size and distance of the plates on the re-
tance of a cell.

Exercise 48 Distribution of a current over a divided circuit.

Exercise 49 Groupings of cells as related to external resistance.

Exercise 50 The electro-magnet. The telegraph.

Following this course will be given lectures, demonstrations and
izzes on the telegraph, the electric bell, the telephone, the motor
d the dynamo. Careful notes of each exercise done by the pupil
ll be made in the laboratory at the time when the exercise is done.
ch laboratory exercise will be followed by a quiz on the prin-
les involved in that exercise and on the practical applications of

those principles. Many collateral experiments, not mentioned here, will be performed by the teacher and used as a basis for questioning. Finally many problems will be set for the pupil to solve, involving the principles of both laboratory and lecture table exercises, and the discussion of some good textbook will be carefully studied after the pupil has completed his notes on a given exercise, or group of exercises.

The writer realizes how meager and fragmentary this outline is, and how much valuable material has been omitted. The time allotted to his department by the authors of the curriculum is four periods of about 40 minutes each a week for one school year, and even that is granted with the condition that for one of these periods no prepared work shall be required. It is easy for any teacher of physics to see that the time assigned is insufficient for any well rounded course in the subject. The struggle in preparing the above outline has hardly been for a survival of the fittest, but rather for a retaining of the absolutely indispensable. It would have been easier and more satisfactory to prepare a much longer course.

I would like as a representative of the association of physics teachers to express again in this part of the country the very high estimation in which that association has held the work of Prof. Hall of Harvard university in building up and developing laboratory physics. Indeed, we regard the work of the university in general and of Prof. Hall in particular with a high degree of respect, I might say almost with veneration, which, when Prof. Hall requested two or three years ago that we make some specific recommendations, prevented us from complying. We did not think it proper to presume to make specific recommendations; and I have no doubt that our attitude in that matter must have made us seem to Prof. Hall like "children crying in the night," "and with no language but a cry." However, we managed to make two general recommendations, one of which, we are very glad to acknowledge, has been met. The recommendations were as follows:

1 We requested that the number of experiments which might be used in preparation for Harvard college be somewhat enlarged.

Instead of the 45 from which we might choose 40, we requested that a very much larger number be prescribed from which we might choose; and you all know what a fine revision in response to that request has been made of the course and of Prof. Hall's textbook in preparatory physics.

2 Moreover, as we spent a great deal of midnight oil over the note books, which we suspected might not be very influential in deciding the fate of our candidates in examination, we requested that a considerable amount of credit be given to the evidence contained in note books. What response has been made to that request I do not know, but we are very glad to bear testimony to the good work that Prof. Hall's department has done for teachers of physics in the New England schools; and we hope and confidently expect that all over the country the same close articulation between the departments of physics in the high schools and in the universities will be brought about. We hope that Columbia and Cornell will even exceed Harvard in encouraging and fostering the subject of physics in preparatory work and will cooperate with us in demanding and finally securing a larger time allotment in the programs of secondary schools.

**Inspector C. N. Cobb**—I ought to say perhaps in the beginning that the regents so far as they are concerned are more than glad that this work has been undertaken. We are painfully aware by reason of our continued and continuous visiting of schools in this state, that the work in physics is not what it ought to be. It is true also that we have means other than visiting the schools from which we are able to judge somewhat of the work in physics, the examinations. I am inclined to the opinion, however, that the public in general attach more weight to the examination system than is attached to it by our office. We believe most fully and firmly that it is but a means and but one means to an end. I happened to be one of the few persons, I think, who returned this list of experiments, and I want to say that when I received the list in the summer time I ran over it cursorily. I thought it a good list, but thought there were some serious mistakes in it. Later in the day I had opportunity to spend a little more time on it and after looking it over somewhat more carefully I began to question a little bit whether some of the things which I had first considered radical errors were errors after all. That evening I examined it with a great deal of care and the next day I believe I spent considerable time on it, and I think about the third day I returned it to Prof. Hallock with the statement, substantially, that I was practically converted to the list as it stood. That of course did not help him at all, but I think the list has helped me to a certain extent. Most of you who are present, being New York teachers, know, but for the benefit of those who are not New York teachers and do not know, possibly I ought to say that the regents are this year revising their syllabus, it being our custom to make a revision once in five years, believing that the work ought to be looked over carefully for revision as often as that, but that to do it more frequently is not desirable for many reasons. It is therefore exceedingly timely, viewed from the standpoint of our office, that this report is made at this time. Personally I feel very strongly that the ideas advanced by Prof. Hall—those suggested by the committee from the National educational association—are exceedingly forceful and helpful. This thought occurs to me, and it has been talked over more or less in our office, that possibly it would be a good plan to require a minimum of time to be spent in laboratory work in connection with a series of experiments. It is also a thought in our minds that the list of experiments should include more than it is expected the students will perform, but that it should be divided somewhat as this is, and that then a requirement should be made that a certain number from each section be performed. Those who are familiar with our question system know that we believe in the alternative system of questions; and we feel that this matter of alternative experiments would be in accordance with that and would meet our views excellently. I think I may say that unless we see some strong reason to the contrary, in the revision of the syllabus we shall strive to incorporate practically the plan outlined by Prof. Hall. I think it probable that the list of experiments given here will be printed in the syllabus, as suggestive of what we want the schools to do. Some of you are not so painfully aware as I am of the fact that in some of the schools where hysics is taught and in some where it is taught from a textbook easonably well, there is practically no equipment for doing work in ny other way. We believe that this condition so far as possible hould be remedied, and those of you who are New York state peole know that we stand ready at all times to pay one half the expense f remedying that condition of affairs in the schools. We believe so trongly in the matter that we are considering the advisability of not nly paying one half the expense but of requiring the schools under he supervision of the regents to equip themselves with some sort of aboratory facilities for the teaching of physics if they purpose to each physics. We doubt the expediency of requiring a school to each physics, but if it does teach physics we believe that it ought to e equipped to a certain extent. We have made some little movenent in this direction with regard to other subjects, requiring maps nd globes and a very meager beginning toward an equipment for eaching physiology.

**Prof. Irving P. Bishop**—Some years ago I was asked to write a aper on a subject about which I had very meager information. eeling some diffidence regarding the task I asked a friend of coniderable experience in such matters what I should do. "Well," aid he, "if you don't know anything about it, you are just the one o write the paper; for then there will be at least one person who will now something about the subject when you are done." I suppose he same principle has guided those who have selected me to discuss he regents syllabus. I was not told that I was to speak on this subect till last evening, and I have had less than half an hour in which o review the outline of topics. In general it includes a fair list of he things which secondary pupils may reasonably be expected to know. Doubtless the experience of the examiner has already suggested additions and changes; and the recent advances in chemical knowledge will compel others. These alterations, however, will not materially change the scope of the work. A principle, more or less, does not matter much in the final result. But in the feature of laboratory work I think I may safely offer a few suggestions.

Our discussion this morning has shown a difference of opinion regarding the relative amounts of time that should be given to class and laboratory work respectively in the subject of physics. A large part may be done experimentally and a small part be class work, or vice versa. The choice will depend on the taste or training of the teacher. Good results may be obtained by either method. But chemistry is preeminently an experimental science, and the best results can be obtained only by experiment. The pupil, to be sure, may be able to study the book alone, without laboratory work and pass an examination. I will agree to take a class of reasonably bright pupils and with this syllabus as a guide make them all pass a creditable examination in eight or ten weeks. But the class would have very little real knowledge of chemistry, and what little they did have would be soon forgotten. The great fault of the present syllabus lies in the fact that the above described condition of things is possible. Laboratory work should be a *sine qua non* in every instance. Instead of saying that note books " may " be called in, the syllabus should make the submission of the note books obligatory. A definite list of experiments should be prescribed for all students, notes should be taken in the laboratory, certified to by the teacher, and the note books forwarded to the regents with the final examination papers. An additional list of desirable experiments, supplementary to the main syllabus might be included for the purpose of broadening the work. The only objection to this plan that occurs to me at the moment is, that it would impose additional work on the regents office. I do not know whether it could get through 30 note books in an hour or not. I fear the alternative condition would prevail. Still the results would richly repay the additional labor by increase of interest and by that better quality of knowledge which comes from actual contact with the object under study.

**Prof. William Hallock**—I may be permitted, perhaps, to make one remark with reference to the list in the way of explanation, and that is this—that it was not intended by any means by the committee that any school, or any teacher, should be held even to a selection from this list. If there are teachers of physics who are in a position to get up a good list of physical experiments, I think they will be very sure to find it recognized. The list was intended primarily for the large percentage of unfortunate teachers that are compelled to ach everything else under the sun and incidentally physics, and ave, of course, no time to go to work and produce a list of experiments. I think we would be the last ones to hamper in any way the dividuality or liberty of the good teachers of physics.

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**General session, Friday, 11.50 a. m.**

# THE ACTIVE METHOD IN NATURE STUDY

## ABSTRACT

Y DR CLIFTON F. HODGE, CLARK UNIVERSITY, WORCESTER, MASS.

The idea " nature " is possibly the most complicated idea in the uman mind. We each have our individual conception of the term. To me nature is a boundless stream of forces, flowing forever and ontinually effecting results of stupendous import to mankind. The nd result of it all is the education of man, i. e. the lifting of the race up to the highest and most efficient possible response to the order of nature. It is man's highest duty to learn enough to control, to respond rightly to, every movement of this vast scheme. With the forces of nature under perfect control, man will come out into a love of nature wholly impossible before.

We fail to realize fully the enormous sweep of natural forces, which, since the dawn of intelligence, or, better, since the dawn of vital response, has been the great schoolteacher of all living things. No seed is so tiny but that within it lies the power, under favoring conditions, to overgrow the continent or the world. How little a thing is it to lay an acorn in some sheltered spot; the forces of nature will build a tree that will stand for centuries. No insect is so tiny that it may not lay a burden of taxation on human life and industry a hundredfold more grievous than the cost of good government, and even of war. The most minute of all living things, the bacteria, give on the one hand, in ultimate analysis, the main food supply of animal life; on the other hand they may cause the sickness and death of millions of animals, even of human beings, annually.

### DIFFERENT METHODS OF NATURE STUDY

The book method, judging from the enormous flood of nature study books on the market, threatens to drown other methods. Any book that takes the place of the child's own senses and experience is out of place in nature study, and should be avoided.

Then we have the logical method, in which the whole realm of nature, from the sun, moon and stars down to pebbles and grains of sand, is laid out in such orderly fashion that it would seem from some systems which I have examined that a child might think he had learned everything worth knowing by the age of 15. This is the gravest calamity, educationally, that can happen to a child. A similar calamity happens to a little cucumber when it turns a beautiful autumnal yellow before the blossom falls off.

The "laboratory method" of nature study has grave defects. 1) Nature is too big to get into any laboratory and we do not want to bring it in by bits and fragments; for it ceases to be nature study when we destroy its wholeness and the interrelations of its parts. 2) We do not wish to introduce formal laboratory methods into the elementary schools. Are we not in danger, in our laboratory courses, of entirely losing sight of the true conception of science as the active, unceasing struggle of the human mind after truth? This struggle, as Lessing conceived it, is so full of the bounding joy of human action that he would prefer the struggle after truth to the actual possession of truth itself. Laboratory work aside from this living spirit of science is a dead grind, as profitless as any of the hollow disputations of the sophists and as much more dreary than the "grammatic bogs and shoals of medieval classicism" as it is apt to be more disagreeable.

Another which we may call the esthetic method of nature study would take nature as we find it, and be content to see the beauty in it. This has a strong attraction for the teacher, and is the method which, it seems to me, is in the greatest danger of turning the proper relations of things upside down. Huxley has well stated the case as follows:

> " In these times the educational tree seems to me to have its roots in the air, its leaves and flowers in the ground; and I confess, I should very much like to turn it upside down, so that its roots might be solidly imbedded among the facts of Nature, and draw thence a sound nutriment for the foliage and fruit of literature and art. No educational system can have a claim to permanence, unless it recognizes the truth that education has two great ends, to which everything else must be subordinated. The one of these is to increase knowledge; the other is to develop the love of right and the hatred of wrong." He continues: " With wisdom and uprightness a nation can make its way worthily, and beauty will follow in the footsteps of the two, even if she be not specially invited; while there is perhaps in the whole world no sight more saddening and revolting than is offered by men sunk in ignorance of everything but what other men have written; seemingly devoid of moral belief or guidance; but with the sense of beauty so keen, and the power of expression so cultivated, that their sensual caterwauling may be almost mistaken for the music of the spheres."

The beauties of nature are made to be enjoyed in peace and quiet, and for the purposes of active nature study I would have our schoolhouses and homes surrounded by and full of them; but caterwauling about them is no high activity of the human soul; it detracts from enjoyment, and the less of it the better.

There is the museum method of nature study. After wandering through the miles of aisles and galleries of our National museum the tourist is apt to get a peculiar pain in the back of the head, sometimes known as the " museum headache; " and after a few such experiences he perceives that the chief function of show museums is to give one a " museum headache," and, unless he has something definite to do or learn from some small part of the collection, he will prefer to enjoy the fresh air outside. A good service of these vast museums is to demonstrate vividly to us how infinite in variety the forms of nature are, and how futile it is for us to try to study and learn, in any fruitful way, more than a very small part. When we add to the things on the surface, as presented in our museums, all the details of internal structure which our laboratory manuals would have us master, the truth is driven fairly home that the chief difficulty in selecting material for nature study is one of embarrassment of riches.

We seem to have gone much too far in the direction of passive learning. The enormous development of modern science may turn out to be a pitiable case of arrested development unless we turn our attention actively to the utilization of what we know. How we can bring about a general utilization of the results of scientific work except through our public school system I am unable to conceive. The museum method does not serve this purpose, specially in elementary work; it contains little motive power and inspiration to go beyond learning the names of things and a few external characteristics.

Another method of nature study we may call the "knot-hole" method. It consists typically in picking up on the street, anything—a sliver of pine, a straw, a broom splint, any bit of garbage, or a knot-hole, and spinning a most wonderful web of fine yarn about it. We may begin with a knot-hole and evolve a pine tree, its mode of growth and branching, a pine forest, logging, lumbering, milling and a host of other things. By this method the teacher need never be at a loss for illustrative "material" and one thing is as good and as good for nothing as another. I fail to see how any real gain in knowledge is made or any growth in love of right or hatred of wrong; hence I would not give it a place among fundamental methods.

By the *active method* of nature study I mean the kind of activity that animals have in their work and play, that which a hound develops in a chase, unconscious of trifles, his whole being devoted to catching something worth his while. It is the activity of the child in his spontaneous play or self-active work, the activity of the true artist or the true scientist—not the hack—whose whole soul and very life are in his work. We could ask for nature study nothing higher than this, which is, I take it, essentially Fröbel's theory of education as the "guidance of intelligent beings to the apprehension of their life work and the accomplishment of their destiny."

In that very early period of life, before formal schooling is begun, the child learns by what we call the natural method. He learns things, realities about him by direct contact; he feels, smells, tastes, sees, hears the objects about him, soaking in unconsciously, as it vere, an infinite amount of information. An important feature of he natural education of the child is that it is so largely active rather han passive. He learns by acting, doing and trying to do all nanner of things. Modern education is trying to get back to this nethod of childhood in all departments, from the university to the indergarten. And it is by drawing out the best activities of the hild that we shall make the most progress in nature study.

In the city of Worcester the public school children have begun to ake a hearty interest in the trees and the birds, and many have been hanged from vandals into considerate and thoughtful protectors of lants and animals. This change has been wrought by distributing o the children a few flower seeds and encouraging them to rear lants at home. The element of competition has been introduced nto this work in order that each child may put his whole soul into naking the plant grow as well as possible.

Think what a large lesson the child gets from this exercise. In rder to rear the best kind of plant how much he must learn about oils, warmth, moisture, sunlight, plant diseases and the insect enemies of plant life. He studies the problem of making two blades f grass grow where only one grew before. In giving this lesson we lace the child in the great tide of human effort.

It is no argument against this kind of work that many of the hildren were unable to distinguish their flower plants from weeds nd that at the end of the first trial a large proportion of the plants ubmitted for inspection were common weeds. In fact nothing ould more fully demonstrate the value and necessity of such work. How many people grow up in civilized communities who have never lanted a seed, who can not tell a flower plant from a weed! How many incapables in the industrial world owe their failure partly to such ignorance as this! I would certainly prefer that a boy of mine should learn how to raise one plant well rather than learn the names of a hundred plants.

There is no reason why such a course of nature study should not lead up to the cultivation of strawberries and other small fruits, and even of fruit trees. Such work has been planned for the Worcester schools.

Then will come the study of the pests that annoy and kill the plants. The children can readily learn, without leaving the city, how to know and deal with the codling moth, tent caterpillars, canker worms, cut worms, aphids, rose beetles, flies, mosquitoes, etc. With proper encouragement we might in time have our school children possessed of sufficient knowledge to rid our cities of these insect pests, and save our orchards and gardens an immense amount of damage each year.

This study will enlist the active interest of children in our animal friends. They will respect and protect the birds and bats and toads when they know of their valuable services to the community. This fact has been fully and very satisfactorily tested in Worcester.

## Discussion

**Prof. Wilbur S. Jackman**—I thoroughly agree with the points brought out in the paper of this morning. I think we shall all come to the opinion at last in nature study, that field work must be the basis of the whole study. I was very much interested in the paper of Prof. Hodge and specially am I interested in his query as to the reason why children learn so very much in the short time that they live before they enter school. Possibly I may be able to suggest an answer to this. I think it is largely owing to the fact that during that time they are not in school. And one reason, perhaps, why that learning period is prolonged beyond that early age is that, even afterwards, they are not in school all the time. I think that the school has made a serious break in the child's learning by taking him out of the midst of this great wealth of material and by trying to narrow his attention at once to a few things. Some one has said that an experiment is a question put to nature. It seems to me for our purpose we can make a better definition; that an experiment is an attempt to answer a question which nature has put to the child. It is utterly useless to talk about laboratory work till a question has been asked of the child by nature. When that question has been asked, then the laboratory method will take care of itself. We little realize what a wealth of material we have about us. As I look back over my experience I am amazed to see how long it has taken me irly to appreciate the real value of the simple things the children ive around them. When I began to teach the subject of germiition I sat up nights trying to keep the plants in window boxes om freezing to death. The course of study put the topic down for ebruary. I should have waited till April or May, when the whole rth is alive with its germinating hosts and then all nature would ive helped me. The best work of that kind that we have ever done as carried on by children by means of outdoor studies. They ere not studying beans or any other of the " set pieces," but they ent right across the street into a vacant lot and followed throughout e year the story of the common ragweed. They began when the ants first showed their two leaves, and by taking the temperature the air and soil, from week to week, they learned something defite about the normal conditions of growth. They were interested the great number of plants that the lot produced. When the upils came back in the fall they took the finished product, if the ed can be so called, and studied that. And so if we take hold of ery question that is presented by nature, the children will become ually interested in all these things.

It seems to me, the first desire which the child has is for the eautiful. We do wrong if we do not recognize this. His first assification of things in this world is the beautiful and the " uneautiful." They are not attracted to those things that they say are ot beautiful. That, at least, indicates a natural interest that we may egin with. I am not afraid that they will stop short of the scientific udy of nature, because in their earlier years they have been enouraged in their love and appreciation of the beautiful.

**Friday afternoon**

## USE OF THE MICROSCOPE IN SECONDARY SCHOOLS

BY INSPECTOR A. G. CLEMENT, REGENTS OFFICE

Not long ago I examined a book bearing the title *Evenings at the icroscope.* It gave a description of numerous minute objects as een when highly magnified, hairs, feathers, scales, tongues and feet of insects and various other objects of more or less interest. There have been schools in which the examination of such objects as these constituted the work done with the microscope. There was, however, no method in the work, no study of related facts. The microscope was used merely to excite wonder in the child's mind. Such is not the prime function of the microscope in the secondary school.

The acceptance of the cell theory, and the recognition of the evolution of life from small unicellular organisms simple in structure and function, but not observable to the eye unless magnified, through a series of organisms of constantly increasing complexity of structure and differentiation of function, organisms visible yet made up of minute cells, have broadened the subject-matter of the sciences of life. This subject-matter is gradually finding its way into the textbooks used in our schools and teachers are learning that it can not be fully explained by words alone. They can tell their pupils about the cell and about the complexity of organs composed of numerous cells, but without the aid of the compound microscope they can not demonstrate objectively the structure of the unit of physical organization, the single cell. The prime function of the microscope, then, in the high school is to enable the pupil to study the phenomena of unicellular organisms.

I am aware that there are those who insist that the pupil should use his eyes unaided as much as possible; that, when he has learned to observe well with the eyes alone, he should use a common lens, followed by the use of the lower powers of the microscope, and finally by the use of the higher powers. This is undoubtedly true in the study of the structure of some objects, as gross tissues of animals or plants, but for the pupil beginning the study of zoology or botany with the idea of examining the fundamental structure of animals or plants and considering their gradual evolution from lower to higher forms, from simple to more complex organization, this plan does not seem feasible.

As few schools in our state possess more than a single compound microscope, in this paper it will not be supposed that each school is so fully equipped that there is a microscope for every two or three pupils; the attempt will be to portray a possible phase of the use of

microscope preceding its complete introduction into our schools.
aring this fact in mind let us consider briefly its use in the study
zoology, botany and physiology, respectively.

In zoology the pupil should begin with the study of one of the
icellular forms, the amoeba, the paramecium or the vorticella. Let
specimen be mounted and the microscope be adjusted by the
cher. The teacher should tell the pupil just what he is expected
see before he looks at the mount, making use of micro-photo-
aphs if feasible, and if not, of drawings made by himself. This
ll be necessary inasmuch as the pupil will probably not be skilled
observation, and the time of observation for each pupil will of
urse be limited. The pupil should make drawings and notes of
observations which should be submitted to the teacher for
ticism. The teacher should let the mount stand and encourage
h pupil to study it at odd times, during intermissions and after
ool hours, endeavoring to discover how it eats, how it assimilates,
w it grows and how it reproduces. The pupil should be taught
t this small organism has all the essential properties of life, con-
ctility, irritability, power of assimilating food and power of repro-
ction. It moves, feels, grows and multiplies. He should be
ght that this minute organism exhibits the simplest forms of di-
stion, respiration, motion, feeling and reproduction; that higher
ms are organized by the multiplication of these units or by ag-
gations of these cells and that the phenomena of all higher forms
life are the same, only carried on under conditions of greater com-
xity. Though, as we study the higher species, the microscope
y be used to show the structure of the various parts of animal
gans, it performs its prime educational function in the study of
ology by making clear to pupils the cellular structure of animals.

In botany a similar plan should be pursued. Beginning with a
gle celled plant as protococcus, study its life history. Then take
lant as spirogyra in which the cells though joined are nevertheless
ily discerned as individual cells. As in zoology the mount should
kept for some time available to the pupils, till each pupil has
en allowed to study and make drawings of it. After this the
ger cells of a moss leaf may be studied and then the layer on layer

of cells as seen in heavier leaves. By this time the pupil will grasp the idea that a whole plant is made up of individual cells. However much the pupil may afterward examine pollen grains and various prepared tissues, this preliminary work should and can be done in a class of good size even with a single microscope. If this work is done the pupil comes to understand the form, structure and function of plants in their simplest manifestations, and thus is enabled to understand the complexity of higher forms more easily and more completely.

In physiology as in zoology and botany the first use of the microscope should be in the study of a single cell. The amoeba is for this purpose probably the best object for study. Here is an animal without stomach, heart, arteries, veins, lungs or brain, and yet it performs all the functions necessary for life, it assimilates food, grows and multiplies. After the pupil has studied this the teacher can easily explain how each part of the human body is composed of a multitude of living beings called cells, each of which eats and grows like an amoeba, one collection of cells forming muscular tissue, another osseous tissue, etc. These various kinds of tissue can easily be examined if the school has provided the mounts. The teacher should also provide for the examination of blood corpuscles, in which the pupils always take great interest.

An experiment entirely practicable with only a single microscope is the examination of the circulation of blood in the web of a frog's foot. The teacher should secure the frog before cold weather and keep it in some place available for use.

Of course much more than has been suggested in this paper is desirable, but it seems wise to endeavor to influence teachers to do what is possible with the present equipment in the secondary schools of our state rather than to advise an ideal course which would require a full equipment.

A few years ago a microscope was rarely found in the secondary schools of this state. Today nearly every school has at least one instrument and several schools are contemplating the purchase of more. With the gradual introduction of better qualified science teachers into our schools the efficiency of the microscope for educaional purposes will be more fully recognized and its introduction ill be more complete.

The educational value of the telescope is universally recognized, ut its great expense will always prevent its liberal introduction into ur schools. With the microscope, however, the case is different. omparatively inexpensive, it is destined to become a large factor n the educational progress of the future, and one of the duties of his society should be to encourage and foster its use.

## Discussion

**Prin. Edward S. Babcock**—The paper which we have heard inlicates clearly the objects to be obtained by the use of the microcope in secondary schools. The chief object is to obtain a conception of the anatomy and physiology of the smaller plants and animals nd their relation to the higher and more complex organisms. I nost heartily agree with this paper. In the introduction several nteresting subjects were mentioned as being of small value. There re things which the beginner will always see under the microscope when examining an object other than those which we wish him to see, such as bubbles of air, hairs, dust, etc. It seems to me that, in the beginning of the work, it would be a good plan for the student to study at least a few of these objects so that he may be able to recognize them when they incidentally occur on the slide. As the paper has stated, it is almost impossible to give any correct idea of the fundamental structure of plants and animals without the use of a ompound microscope, and this is specially true in zoology and physiology. An excellent thought was expressed when it was said that one microscope can be made to do good service in a school. It is unnecessary in most of our high schools to have more than one, though it would be advantageous to have more. I have found in my own experience that this method works very well. A class can pass, one student at a time, to the microscope and view the specimen which has been prepared. In addition to this students take a great interest in preparing a few simple slides for themselves. In the study of physiology the working up from cells to tissues will be of great use. Few students studying physiology have a fair conception of the various tissues. Connective tissue means very little to them; but after careful study with the microscope these elements become familiar and they know more exactly what they are. I have succeeded in having nearly every one in a class in physiology grind down a tooth and a piece of bone for the purpose of viewing the canals for themselves. It is surprising what an interest springs up when students begin to discover these truths for themselves. I heartily recommend the use of the compound microscope so far as possible. The cost is not great, as has been remarked in the paper, and the additional apparatus that is necessary costs but little if one makes it for one's self. If it were within the province of my discussion, I should be glad to speak of a few very simple pieces of apparatus that may be made by any teacher.

**Prof. Fred Z. Lewis**— All that has just been said about the use of the microscope in secondary schools, I heartily approve. In teaching botany and zoology, I find that I can not get along without it. In fact, I could better spare the textbook than the microscope. In teaching these subjects, it has been my plan to use the textbook as little as possible, making it merely a guide, and to have students trace out for themselves, by careful dissection, and by use of the microscope, the important features observed, and record their observations with illustrative drawings in neatly kept note books.

By studying tissues with the microscope, one understands more fully their nature and functions, and the impressions received are more accurate, as a rule, than those received from textbook study. Few students become interested in the dry description of plant or animal tissues. On the other hand, few fail to become interested in such work when they are permitted to determine for themselves the nature and structure of an organism.

The use of the microscope develops ability to observe accurately. When one begins to work with a microscope, the first impressions received are more or less erroneous, because a faculty to observe correctly has never been cultivated. In order to obtain from the microscope the information desired, a student must bring out in detail the structure of the object or tissue he is studying. This in itself impresses the student with the importance of little points, on hich a great deal may depend. It has been my observation, and )ubtless yours, that the majority of pupils who fail in any subject 'e the ones who have been careless in the important little things, ıd have never known the meaning of the word thorough.

The value of the microscope in secondary schools varies somewhat :cording to the subsequent course of the student. To one intend- .g to take a college course, be it professional or not, familiarity ith its use is of the greatest importance. Some knowledge of the icroscope is required in all scientific branches. It is admitted by l, that the average student, on entering college, has not the ightest idea of the technic of the microscope, or the art of micro- :opic observation. And the student who must waste valuable time ı college, learning technicalities, when he should already be able to camine clearly and understandingly, tissues presented to him, has, › say the least, not received a practical preparatory course. To one ot intending to enter college, the value is less. But would it not be 'ell even for him to understand a little about the delicate tissues, nd the minutiae of life both animal and vegetable? The education erived from observation, close, accurate and comprehensive, is ertainly worth something, even though one may never use the ıicroscope.

If I am rightly informed, we are behind many western high chools, not only in the use of the microscope, but also in methods ·f teaching botany and zoology. We employ textbooks, charts, nd sometimes exhibit preserved specimens; while in the best schools ›f the west the laboratory manual is used rather than the textbook .nd in place of studying the chart the student performs actual dis- ection of the specimen itself. Would it not be far better for the astern student if specimens were provided for laboratory work, and ıe had the opportunity to solve the problem for himself by using the calpel and microscope?

The study of biology, without the constant use of the microscope, s greatly curtailed in value. Though the student may obtain a heoretic proficiency from the textbook, he has nevertheless acquired ıo practical idea of the tissues he has studied. And ought it not to ɔe our chief aim to develop from our students practical men and women? We ought to train them to make their own investigations, and to draw their own conclusions, guiding them as the case may require, but not teaching them to lean on the opinions of others. I would advocate the use of note books, because it enables the student to impart results to others in a clear, concise and definite manner.

As I stated before the principals association yesterday at Syracuse, I would recommend that the note books in physics, chemistry, botany and zoology be called for and inspected by the regents, and that a certain amount of credit be allowed the student according to the value of the records of his laboratory work. This would soon bring about laboratory methods of study in science, and eliminate the possibility of giving the rhetoric or French teacher a side class in zoology.

**Sup't J. I. Gorton**—I should be glad to have Mr Babcock spend a few moments in further explanation of what can be done in the preparation of simple objects. I believe that the great need of the embryo microscopists in our high schools is simple objects to be viewed, and, farther, we need explanations of these things. Now, on looking at the micro-photo illustrations in the other room, the casual examiner would say, " There are a lot of lines and holes, some big and some little, some long and some round; another has a little different arrangement." That is all he would get out of it. We need some explanation of these things, something that is tangible and can be brought to a focus, rather than the indefinite pictures.

**Prin. Edward S. Babcock**—Muscle may be prepared in several ways. The muscle is hardened in alcohol and a cross section is made, also a horizontal section, and these are mounted in the usual way. For the class preparation I should not try to make permanent slides at all. As a rule better success is obtained if the specimen is placed in water between the glasses. It then retains its normal appearance, whereas if it is dried, it shrivels up and loses its real character. To show the cellular structure or the threads of the muscle, take a piece of veal, for instance, and boil it till it is perfectly tender and then tear it with needles and place a little in diamond dye or aniline dye diluted with much water. Mount in water or balsam. As to liver cells; it is not so easy to make a slide of iver. I am not sure that the amateur will be successful. The ardening process is difficult, but if the specimen is cut up into small ieces and placed in any good hardening solution for several days, t will be hard enough to cut into sections.

**Prof. Charles W, Dodge** –I would like to declare my hearty ppreciation of the ideas which Mr Clement has expressed this afteroon, and I wish they could be in operation in a greater number of chools. I think if the regents office were to be a little more vigorus in this matter, we could easily have more of the study of the inute structure, not only of the lowest animals and plants, but of he higher animals and plants as well, in the secondary schools. I have only one criticism and that has regard to the assertion that a pupil should be informed before he looks into the microscope as to what he is going to see, and a drawing of the object under the microscope be shown. I think the proper way is to let the pupil get his first idea from the real thing, not from some other person's idea expressed in a drawing or description. He may then correct his idea and be led to a further study by means of drawings or descriptions.

Mr Clement told us what we should do, but did not have time to tell us how to do it. There is no reason to suppose that a person who has had only general scientific training is competent to prepare a well-mounted specimen for the microscope, for the preparation of slides for microscopic observation is by no means child's play and the mounting of such specimens is an art in itself. When one comes to study the structure of organs like liver, kidney and brain, then I see no other way than to purchase from some dealer specimens prepared by persons who have had experience in the work. But as for cutting a section of a liver or kidney with an ordinary sharp knife and then expecting to see anything definite, it is absolutely impossible. I remember the story of a teacher of botany in one of the central towns of this state who read in the book that, if she wished to show starch grains or cells, she should take a sharp knife and cut a section of a potato. One of the pupils who saw the section said that it was suitable in size for making Saratoga chips.

When it comes to the manipulation required for mounting permanent specimens, we would better leave it to some one who knows how. Each tissue requires special treatment by itself. For information we must simply go to the treatises on histology. Many of these will tell us about the simpler kinds of work. As for telling any teacher of science what this or that detail of structure means for a certain section of tissue, it can not be done in advance. It may be a normal feature or an injury which has occurred through manipulation of the specimen, or it may be due to various causes, and the proper explanation can be given only by some one trained in that line of work.

My contention is that nothing but prolonged and serious study under proper supervision will prepare a person to teach zoology or microscopic anatomy or any other branch of science. These subjects require properly trained teachers just as much as do the languages and mathematics.

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**Prof. William Hallock**—The list of experiments that was under discussion this morning, prepared in connection with the report of the subcommittee on physics, is intended for the guidance of teachers. It is not intended that the student or teacher shall cover the whole of the list in a given length of time, nor is it intended that it shall be a fetter on the freedom of instruction. It is intended simply as a guide for those who need help, and others need pay simply so much attention to the list as its merits require. The desire of the committee is that the work done so far receive the approval it may deserve, and that the committee now be permitted to go ahead and prepare, with reference to this list of experiments, a few more details, such as reference to various methods and reference to literature and available apparatus. The list of experiments presented here represents the work of the committee so far, and we expect to amplify on that as a basis.

**Prof. I. P. Bishop**—The one science subject about which there seems to be most confusion at present is physiology, with special reference to the teaching of narcotics and stimulants. As the result of a somewhat extended inquiry among teachers, I find that the colleges are teaching it one way and the secondary schools another.

here is disagreement not only regarding quantity and method but lso as to fundamental facts. Whatever other differences of opinion ay exist, I think there should be as much uniformity in the treatent of the principles as now obtains in other sciences. Competent eachers from colleges and secondary schools should confer and eparate those facts on which all are agreed from those considered loubtful or hypothetic. A report from such a body once adopted nd given the authority of this association would do much to put hysiology teaching on a scientific basis.

I therefore ask leave to present the following resolution:

*Resolved:* That a committee of five be appointed to ascertain and eport what is definitely known regarding the physiologic effects of lcohol and narcotics on the human body and to recommend suitble methods for teaching the same in the schools of this state. *see* p. 453)

**Prof. C. W. Hargitt**—I believe that I voice the general sentinent of the meeting when I say that it has been one of the best in he history of the association. We have received encouragement hat will aid us in carrying out the work open to us as an associaion. I am glad to report that there have come from various sources ndorsements of the spirit and method of the association. I am very lad to express my own appreciation of the courteous regard of the nembers of the association during the present meeting.

**Friday evening**

## TEN REASONS FOR THE STUDY OF BIRDS

BY FRANK M. CHAPMAN, AMERICAN MUSEUM

Birds are sensitively organized creatures and respond so eadily to the influences of their surroundings, that in their distribuion, structure, and habits they furnish naturalists with invaluable vidences of the workings of natural laws.

In preventing the undue increase of insects, in devouring small rodents, in destroying the seeds of harmful plants, and in acting as scavengers, birds are man's best friends among animals; without their services the earth would not long be habitable, therefore we should spare no effort to protect them.

Our inborn interest in animals, properly developed, will broaden our sympathies and morally elevate us.

They are the most abundant and conspicuous of the higher animals, may be most easily studied and observed.

They are beautiful in form and color, and exhibit an unequaled power of flight, thus stimulating our love of beauty and of grace.

Birds are unrivaled as musicians; their songs are the most eloquent of nature's voices and by association become inexpressibly dear to us.

Their periodic migrations excite our wonder and admiration, and not only connect them with the changing seasons, but so alter the character of the bird life of the same locality during the year, that their study is ever attended by fresh interest. The bird student living in the temperate zone receives visitors from the tropics, and from within the arctic circle.

In their migrations, mating, nest building, and home lives, birds not only display an intelligence that attracts, but exhibit human traits of character that create within us a feeling of kinship with them, increasing our interest in and love for them.

With birds the individual lives in the species; the robin's song we hear in boyhood, we may hear in our old age; therefore birds seem never to grow old, and acquaintance with them keeps alive the many pleasant memories of the past.

In thus possessing so many and such varied claims to our attention, birds, more than any other animal may serve as bonds between man and nature.

## SKETCH OF THE
## EW YORK STATE SCIENCE TEACHERS ASSOCIATION

### Including brief reports of first two annual conferences

The New York state science teachers association was organized 1896 during the Buffalo meeting of the National educational asso- ation, and may be regarded as an outgrowth from the department natural science instruction of that organization. It owes its origin Prof. Charles Skeele Palmer, of Boulder, Colorado, the secretary the department of natural science instruction of the N. E. A., who a letter addressed to the local committee, April 3, 1896, said, "One ovement which I would like to see organized is a state department science teachers in every state. We have such a body in Colo- do, very active and useful, with special committees on physics and emistry, biology, and also on science in the grades."

At the first meeting of the local committee, which was held late in ay at the house of Prof. I. P. Bishop, the chairman, it was decided undertake the carrying out of Sec. Palmer's plan. The following rcular letter was sent out to several hundred science teachers of the ate.

Buffalo, N. Y., June 5, 1896

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We ask your careful attention to the proposed organization of a ate association of science teachers at Buffalo, July 8, at 5 o'clock the Y. M. C. A. building, in connection with the science depart- ent meetings of the N. E. A. for July 9 and 10.

The main object of this prospective organization is to raise the andard of preparatory work in the sciences by bringing the college nd high school teachers into close personal contact with each other.

In this way we shall greatly further the important experimental ork of ascertaining the proper subjects which will some time be cluded in the ideal high school and preparatory courses, as well s the order, scope, and correlation of the various lines of natural cience, the best methods of teaching, and many other points of in- rest to us professionally.

Please come prepared to help: we need enthusiasm, experience, nd a genuine devotion to thorough high-grade work.

The headquarters of the science teachers of the N. E. A. will be at the Genesee, where accommodations may be secured at $3 a day American plan, or $1 a day, European plan.

Signed by the local committee of the department of natural science instruction, N. E. A., Buffalo, 1896

PROF. IRVING P. BISHOP, chairman
DR FRANKLIN W. BARROWS
PROF. HERBERT M. HILL
DR JOHN A. MILLER
PROF. WILLIAM H. PITT
PROF. ADOLF DUSCHAK
PROF. A. W. SHEPARD

The following announcements are made by the

## Department of natural science instruction

Meetings in Y. M. C. A. Hall, Pearl and Mohawk.

*President,* CHARLES E. BESSEY, Lincoln, Neb.
*Vice-President,* WILBUR S. JACKMAN, Englewood, Ill.
*Secretary,* CHARLES S. PALMER, Boulder, Col.

THURSDAY, JULY 9, 3 P. M.

Opening address. By the president, Charles E. Bessey, University of Nebraska.

Address on physics. By H. S. Carhart, University of Michigan.

Address on chemistry. By P. C. Freer, University of Michigan.

FRIDAY, JULY 10, 3 P. M.

Address on botany. By J. M. Coulter, University of Chicago.

Address on zoology. By D. S. Jordan, Leland Stanford jr university.

There will be one or two geological excursions, to be announced later.

A public reception will be given to Professors Bessey, Coulter, Jordan and other prominent members of the department.

The science department of the N. E. A. sends you a special invitation to be present at its meetings at the Y. M. C. A. hall, July 9 and 10.

(Signed) CHARLES SKEELE PALMER, Secretary

Please mail this slip at your earliest convenience to Prof. Irving P. Bishop, 109 Norwood avenue, Buffalo, N. Y.

Date....................1896

I expect to be present at the organization of the New York state association of science teachers, in Buffalo, July 8, 1896.

Name ....................................
Position ................................
School ..................................
Postoffice address.......................

About 75 teachers replied to this letter expressing interest in the roject and offering their support.

The organization of the New York state science teachers associaion was effected July 8, 1896 at 5 p. m. in the Y. M. C. A. hall, uffalo, about 50 persons being present. The meeting was called o order by Prof. Bishop, chairman of the local committee. Dr Ierbert M. Hill, of Buffalo, was then elected chairman of the meetng, and Dr Franklin W. Barrows, of Buffalo, secretary. Dr John L. Miller, of Buffalo, Prof. Adolf Duschak, of Buffalo, and Prof. eorge F. Atkinson of Cornell university were elected a committee n nominations and constitution. During the deliberations of this ommittee the aims and work of the proposed organization were iscussed by Pres. Jacob G. Schurman of Cornell university, Prof. . H. Gage, of Cornell university, Prof. Irving P. Bishop, of the uffalo normal school, Prof. Richard E. Dodge of Teachers colge, New York, Prin. Charles W. Randall, of Lockport, Prof. harles E. Bessey, of the University of Nebraska, Prof. Charles keele Palmer, of the University of Colorado, Dr F. J. H. Merrill, irector of the New York state museum at Albany, Prof. Albert H. uttle, of the University of Virginia, and Charles N. Cobb, inpector, of the University of the State of New York.

The following officers were elected to serve till Jan. 1, 1897:

*President*, Prof. Simon H. Gage, of Cornell university

*Vice-President*, Dr Charles W. Hargitt, of Syracuse university

*Secretary and treasurer*, Dr Franklin W. Barrows, of Buffalo high hool

A constitution was adopted, subject to revision at the first annual eeting. The officers were authorized to organize a board of overnment and with their assistance to manage all the affairs of e association till the first annual meeting.

The first meeting of the officers was held August 24, at the home f A. T. Kerr, Buffalo. It was decided to call a meeting of the ssociation and its friends on August 26, in connection with the seconal meetings of the American association for the advancement f science, then in session in Buffalo.

The following members of the association were chosen to serve s an advisory council till the next regular election:

Prof. Albert L. Arey, Rochester free academy

Prof. Charles L. Bristol, New York university

CHARLES NEWELL COBB, Regents office, Albany
Prof. CHARLES W. DODGE, University of Rochester
Prof. A. L. GOODRICH, Utica academy
Prof. CHARLES S. PROSSER, Union university
Prof. L. M. UNDERWOOD, Columbia university
Prof. IRVING P. BISHOP, State normal school, Buffalo
Prof. J. MCKEEN CATTELL, Columbia university
Prof. LEROY C. COOLEY, Vassar college
Prof. RICHARD E. DODGE, Teachers college, New York
Prof. FRANKLIN W. HOOPER, Brooklyn institute of arts and sciences
Prin. T. B. STOWELL, State normal school, Potsdam
Prof. E. R. WHITNEY, Binghamton high school

Aug. 26, 1896, a special meeting of the association was held at 5 p. m. in room 20 of the Buffalo high school, following the adjournment of the botanical section of the A. A. A. S.

Prof. Bishop gave a brief account of the movement which led to the formation of the association. Pres. Gage, Vice-Pres. Hargitt, Profs. Charles E. Bessey, of University of Nebraska, L. M. Underwood, of Columbia university, and Samuel A. Lattimore, of the University of Rochester, addressed the meeting. After unanimously passing a resolution, offered by the president, expressing confidence in the purposes of the association and the usefulness of the work on which it was entering the association adjourned *sine die.*

December 1, the following appeal was sent to science teachers throughout the state with the program of the approaching meeting.

**You are cordially invited** to attend the first annual meeting of the New York state science teachers association, which will be held December 29-31, at Syracuse, and to assist by your advice and counsels as well as by your presence in the successful inauguration of our work in this state.

We desire to unite in this organization all grades of science teachers, from those of the secondary schools to the university professors, in order to secure that mutual acquaintance and helpfulness which are the aim and end of all educational conventions. Until our association was organized last July during the Buffalo meeting of the National educational association, there was no society in the state for the special promotion of science teaching. The officers are encouraged to believe that the association will receive the earnest support of science teachers everywhere, and that it will not be long efore the existence of a separate association for the six hundred cience teachers of the state will be fully justified by results. To is end we invite your earnest attention to the accompanying pro-ram, and to the claims of the association upon your thoughts. We ust that you will make an effort to attend the December meeting, nd, if that is not possible, we look to you to identify yourself with e organization and to aid in the advancement of our mutual in-erests.

The signs of the times all point to a rising wave of interest in cience teaching. It is not confined to the high school or the col-ge and university, but extends into the lowest school in the state. here is a feeling that science has a vital relation to the life of every uman being and that each one should have opportunity to become cquainted with it both for its practical usefulness and because of s lessons in law and order, and its power to truly cultivate the uman mind. The simple question which confronts us as teachers f science is: Shall we use our knowledge and experience in aiding e wise application of the power in this rising wave of desire for cience teaching?

We are fortunate in having our meeting directly after the 12th oliday conference of the Associated academic principals of the state f New York, which occurs at Syracuse, Monday, Tuesday and Vednesday, Dec. 28-30, 1896.

## First annual meeting

HELD IN SYRACUSE, DEC. 29, 30 AND 31, 1896

PROGRAM

**Tuesday, Dec. 29**

8 p. m. By invitation of the Associated academic principals, this association and the Association of grammar school principals united with them in joint session.

1 Address by Pres. J. G. Schurman, of Cornell university on "College entrance requirements and the high school curriculum." [Reported in the Proceedings of the 12th annual conference of the Associated academic principals. *Regents bulletin* 40]

2 Discussion: "Music in the schools."

**Wednesday, Dec. 30**

9 a. m. Meeting of advisory council at the Yates.

.30 p. m. First session at the high school.

1 The president, Prof. Simon H. Gage, of Cornell university, presented a paper on "The purpose of the New York state science teachers association and the work it hopes to accomplish."

2 Discussion, Physics and chemistry, led by Prof. Albert L. Arey, of Rochester free academy, and Dr E. L. Nichols, of Cornell university.

8 p. m. Second session, at the high school. Discussion on the Earth sciences (Physical geography and geology.)

1 Paper by Prof. R. S. Tarr, of Cornell university, read by Dr Frank McMurry, of the Buffalo school of pedagogy.

2 Discussion opened by Prof. Richard E. Dodge, of the Teachers college of New York city.

**Thursday, Dec. 31**

9 a. m. Third session at the Syracuse university medical college.

Discussion on Biology (botany, zoology and physiology) led by Prof. Charles Wright Dodge of the University of Rochester, and Dr Thomas B. Stowell, principal of the Potsdam normal school.

2.30 p. m. Business session at the Syracuse university medical college.

Adjournment.

At this meeting the constitution was revised and adopted as it stands to-day, (1899).

It was voted "that a committee of nine members be appointed by the president, who shall have power to add to their number as many members as they desire, and who shall report to the association at its next annual meeting, on the three following subjects:

1) The recognition of science as a requirement for entrance to colleges.

2) Science courses for secondary schools.

3) Nature study in elementary schools."

This committee, which has since been known as "committee of nine" was appointed in June by Pres. Nichols and consisted of:

LEROY C. COOLEY, Vassar college, *chairman*
ALBERT L. AREY, Rochester free academy
WILLIAM HALLOCK, Columbia university
GEORGE F. ATKINSON, Cornell university
CHARLES B. SCOTT, Oswego normal school
ANNA B. COMSTOCK, Ithaca
RALPH S. TARR, Cornell university
RICHARD E. DODGE, Teachers college, New York
JOHN D. WILSON, Prin. of Putnam school, Syracuse

Another most important step in the work of the association was taken as the result of a conference of those interested in the teaching of physics. A committee consisting of Profs. Hallock, Arey, and Bishop was chosen by this conference to formulate and present a plan of laboratory requirements in physics suitable to the secondary schools of the state. This committee, after a preliminary meeting at Ithaca in 1897, presented its final report at the New York meeting, 1898.

The following officers were elected for 1897:

*President,* Dr EDWARD L. NICHOLS, Cornell university

*Vice-President,* Dr CHARLES W. HARGITT, Syracuse university

*Secretary and treasurer,* FRANKLIN W. BARROWS, Buffalo high school

### Executive council

| | |
|---|---|
| 4 years | Dr CHARLES W. DODGE, University of Rochester |
| | Prin. HENRY PEASE, Medina high school |
| | Prof. W. C. PECKHAM, Adelphi college, Brooklyn |
| 3 years | Prof. J. McKEEN CATTELL, Columbia university, New York |
| | Prof. LEROY C. COOLEY, Vassar college, Poughkeepsie |
| | Prof. E. R. WHITNEY, Binghamton high school |
| 2 years | Prof. IRVING P. BISHOP, Buffalo state normal school |
| | CHARLES N. COBB, Regents office, Albany |
| | Prof. C. S. PROSSER, Union university, Schenectady |
| 1 year | Prof. ALBERT L. AREY, Rochester free academy |
| | Prof. R. E. DODGE, Teachers college, New York |
| | Prin. T. B. STOWELL, Potsdam normal school |

A full report of the Syracuse meeting, by the secretary, is published in *Science,* v. 5, nos. 116-118, March 19, 26, and April 2, 1897. The address of the president is given below.

## THE PURPOSE OF THE NEW YORK STATE SCIENCE TEACHERS ASSOCIATION AND THE WORK IT HOPES TO ACCOMPLISH

BY PROF. SIMON HENRY GAGE, CORNELL UNIVERSITY

It is a source of congratulation that the science teachers of the Empire state are no longer to remain scattered and unorganized, but by association are to gain the encouragement and enthusiasm which united effort brings. That enthusiasm and efficiency are promoted by such organizations of science teachers is abundantly attested by the results gained through the efforts of the American society of naturalists, and the teachers of Illinois, Colorado, California and of other sections.

An association like this makes it easier for the college and for the secondary school teacher to come together and talk over matters of mutual interest and concern. In these friendly consultations and discussions there will be a chance of finding out something of what is most desirable, and what is practicable and possible in the schools each represents. And in these discussions it will not be possible to forget the children in the elementary schools, the great majority of whom come neither under the training of the high school nor of the college, but must be content to get the best they can from the elementary schools to equip them for the struggle of life which stands so near them. What help have these a right to ask from the high school and the college? And then the great world of thought and action whose mighty stream, sooner or later, draws all into it, what does it demand? It is after all the final court which tries all alike, and puts each to the test whether he be a college graduate, high school graduate, pupil of an elementary school or one who has only his hereditary endowment of mother wit.

The signs of the times all indicate that the high school teacher is to be at least a college graduate, and the elementary school teacher a high school graduate. If this is true, while the college has but few under its immediate instruction, it determines the character of the high school, and in turn the high school determines the character of the elementary school. The college is then the intellectual guide of the land. Is it and has it always been a wise and sympathetic guide?

If we compare our times with those of 500 or even 100 years ago there will be found an immense difference, and science is largely responsible for this difference. Whether we approve or not, things are not as they once were; whether we designate the change as one of progress or decline, there has been change, the world is not what it once was. The modern citizen must adapt himself to these changes or be ground to powder in the struggle for existence or for preeminence. The professional man, if he is a physician, is a criminal if he does not know and apply the science bearing upon his profession; and the lawyer who has only the knowledge that the middle ages might have given him is soon eliminated from the race. It is with hesitation that I speak of the clergyman, but if he misrepresents nature which he might know, and to which he so often reverts for illustration, how can he expect unhesitating acceptance of his words concerning the profound mysteries that all, even the most favored, must "now see through a glass darkly." The artisan, the farmer and the business man can not live as did their forefathers; and so from the professions, from all the people there comes an appeal so earnest, so pressing that we can not choose but hear. If they suffer for lack of knowledge we must do our best to supply the knowledge. In place of lofty isolation, or worse, of indifference, we should give them the science we possess, show them the way it is gained, and how much there is yet to be gained and thus make every boy and girl and through them every man and woman in our great state an observer or original investigator in science. This can come about only when real science is taught and studied, only when the fog of opinion and baseless authority is brushed aside and the pupils in the schools are brought in direct contact with nature, and there learn to appreciate and apply the scientific method so admirably stated by St Paul: "Prove all things, hold fast that which is good."

Our association ought not and can not stop with the work of the high school. From the elementary schools most pupils must enter upon the labors of life; they make the bulk of the state, and a noble patriotism should lead us to do all we can for them. On the principle of self preservation also such help is wise, for the work of high school and college alike have their foundations laid in the elementary school. As the college reaches down to help and encourage the high school so should the high school reach down and help and encourage the elementary school and thus will it come about that every child in the state will be brought into direct contact with nature where he can experience for himself her inspiring and uplifting sympathy.

If this program is to be carried out, the college must train its students and prepare them to take the true science, science at first hand into the high school and banish therefrom anything savoring of sham. Then the college must honor its graduates by accepting for entrance the work in science of the high school on equal terms with other subjects taught by its graduates. To bring this about, I take it, is one of the duties of this association. Thanks to the work of the American society of naturalists, and to the many able men and women who have worked for the same end, science work done in the high school is at the present moment recognized by a considerable number of colleges. [See *Science*, Dec. 25, 1896]

It is discouraging, almost prohibitive for the college to say to the secondary school: When you reach the proper degree of excellence in your science work, the college will consider your appeal for recognition. Why can not the college state fairly and explicitly exactly what the standard of excellence should be and with equal fairness and justice say, When your students reach this standard we will accept them for entrance on the same terms as for other good preparatory work? No true friend of science would ask the college to admit students with a training in science inferior to that required in the older disciplines. Let the college make its standard as high as it will, but let it recognize the work that comes up to its requirements, and thereby honor its own graduates who have so worthily brought the work of their pupils up to the high standard. Such recognition would put science on a fair footing with the other disciplines. It would encourage and inspire the teacher in the secondary schools and help to give his work a dignity and importance in the eyes of his pupils and colleagues which it can never have if it is not honored by the college. Men still respect and honor what the college approves, and it is a part of our work to see to it that the college puts the seal of its approval on sound learning in science as well as on that of the other disciplines which it accepts for entrance to its halls.

It seems to me that the way before us is clear. Changed conditions have brought new needs, needs that knowledge of science can alone supply. We should do our best to help our day and genera-ion, and in giving it the help of science and the sympathy of nature feel confident that we are doing right in every way. Science aught as every true teacher will teach it, will help the students to gain an insight into nature, will bring them face to face with reality, with law and order, and certainly will form at least one element in a noble education. It will emphasize the old lesson, that power over nature comes only by obedience to her, and by this obedience which can come only through understanding, discipline is gained. By action in accordance with law which is understood, and by reflection come culture. With this discipline and culture come large ympathies and a wide outlook upon the universe. There comes lso the consciousness that while the current of life and law is irreistible, man is a part of the mighty current and his will has its due hare in directing it.

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Aug. 19, 1897, a meeting of the executive council was held at he Queen's hotel, Toronto, for the convenience of those members who were attending the meeting of the British association for the dvancement of science. Pres. Nichols, Messrs Arey, Cobb, C. W. Dodge, R. E. Dodge, and Barrows were present. As a result of ecommendations adopted here, Ithaca was selected as the next place of meeting and the council committed itself to the plan of holding two meetings of the association each year.

## Second annual meeting

ITHACA, DEC. 30-31, 1897

### PROGRAM

#### Thursday, December 30

2.30 p. m. Registration of attending members at the headquarters of the association in Boardman hall.

3 p. m. Opening session in the physical lecture room, Franklin hall.
Address of welcome. By Pres. J. G. SCHURMAN.

3.30 p. m. Physical laboratory work in secondary schools.
- *a* Shall it be principally qualitative or quantitative?
- *b* How much time shall be given to it?
- *c* Supervision.

Paper by Miss MARY E. DANN, of the Girls high school, Brooklyn.

4 p. m. **Discussion opened by Prof. John F. Woodhull, Teachers** college, New York; followed by Prof. D. L. Bardwell, of Cortland normal school, and Prof. Irving P. Bishop, of Buffalo normal school.

4.30 p. m. Business session of the Association.

8 p. m. Evening session in the physical lecture room.

Address by the president of the association.

Use of the lantern in science teaching (illustrated by numerous experiments).

After the evening session there was an informal reception at the house of the president, 5 South av., campus.

### Friday, December 31

9.30 a. m. Report of the committee of nine on the three following subjects:

1 The recognition of science as a requirement for entrance to colleges;
2 Science courses for secondary schools;
3 Nature study in elementary schools.

10.30 a. m. Discussion of the report.

11.15 a. m. The teaching of botany in secondary schools.

Paper by Prof. L. M. Underwood of Columbia university.

Discussion by Miss Sarah V. Chollar of Potsdam normal school; followed by Prof. W. H. Lennon of Brockport normal school.

2 p. m. Round tables for discussion of science teaching, as follows:

Union schools and academies, led by Prin. Thomas B. Lovell of Niagara Falls high school.

1 Value of science teaching:
  *a* As an aid to the student in other studies;
  *b* As essential to the habit of accuracy;
  *c* As essential to success in his life work, or in his college course.
2 Science teaching in high school departments.
  *a* What subjects and how many?
  *b* Method of teaching; use of textbook; how much original work? What results to be expected from this study?
3 Science or nature teaching in graded departments of secondary schools.
  *a* To what extent can we apply the methods of the high school departments?
  *b* Manner and method of nature study in grades between the fourth or fifth and the high school?
4 Can the above work, as demanded by this round table, be accomplished by the average school?

Normal schools, led by Prof. HOWARD LYON, of Oneonta normal school.

Character and scope of science teaching in normal schools in anticipation of the needs of secondary schools.

*a* Fewer but fundamental subjects;
*b* More time;
*c* Instruction of highest order giving experience in real scientific investigations

In order that—1 Students of union and high schools may be ready to take advanced work in college.
2 Those whose training ceases with the high school may have a clear notion of self-study in science.

Colleges, led by Prof. B. G. WILDER, of Cornell university.

Shall we include the physical and natural sciences among our subjects required for entrance to college?

3 p. m. Paper: Out-door science work in secondary schools, by Prin. FREDERICK A. VOGT, Buffalo central high school.

Discussion opened by Prof. A. D. MORRILL, of Hamilton college, Clinton; followed by CHARLES B. SCOTT, of Oswego normal school, and Prof. R. A. SURFACE, of Cornell university.

4 p. m. Final business session and election of officers.

It was decided to hold only one meeting of the association annually, and that during the winter holidays. Members were requested during the coming summer "to attend the several educational meetings held throughout the state and to see that science teaching is adequately represented on the programs."

It was decided to meet at Teachers college, Columbia university, in 1898.

The following officers were elected for 1898:

*President,* CHARLES W. HARGITT, Syracuse university

*Vice-President,* JOHN F. WOODHULL, Teachers college, New York

*Secretary and treasurer,* FRANKLIN W. BARROWS, 45 Park st., Buffalo, of Central high school

## Executive council

### FOR FOUR YEARS

Prof. WILLIAM HALLOCK, Columbia university, New York
Miss MARY E. DANN, Girls high school, Brooklyn
Prof. D. L. BARDWELL, Cortland normal school

Prin. THOMAS B. LOVELL, Niagara Falls high school, (elected to fill out the unexpired term of Prin. Henry Pease, removed from the state).

The general reports of the Ithaca meeting, by the secretary, were published in *Science*, v. 7, no. 174, Ap. 29, 1898, and in *School journal*, New York, v. 56, nos. 12-13, Mar. 19, 26, 1898. The preliminary report of the committee of nine was published in the *Journal of pedagogy*, Syracuse, v. 11, no. 2, April 1898. Dr Underwood's paper appeared in the same number. Miss Dann's paper was published in the following number of the same journal, July 1898. An abstract of Prin. Vogt's paper appeared in the *School journal*, v. 56, no. 21, May 21, and an abstract of Pres. Nichols's lecture in the same journal v. 57, no. 20, Dec. 3, 1898.

During the summer and fall of 1898 three conferences of the executive council were held, no quorum being present. The first conference was in Boston during the meeting of the A. A. A. S., the second in Rochester, on Oct. 14, and the third in Buffalo, Nov. 22. The most important result of these meetings was the arrangement between the council and the regents of the University of the State of New York, by which the regents agreed to print and circulate the program and report of the next meeting.

## NECROLOGY

**Henry Clarke Coon,** M.A. M.D. Ph.D., was born Jan. 28, 1828, at West Edmeston, Otsego county, N. Y., and died May 9, 1898, at Alfred, N. Y. He attended an excellent district school and had access to a valuable library which early inspired him with a love for learning.

At 19 he entered DeRuyter institute, DeRuyter, N. Y., where he spent nearly two years. For several years thereafter he was engaged in teaching in district schools and academies.

From 1860-64 he taught in Hopkinton academy at Ashaway, R. I. In 1864 he entered college in the classical course in Alfred university, graduating with the degree of B. A. in 1868. For the succeeding three years he taught Greek and natural sciences in DeRuyter institute. The year 1871-72 he spent in the New York homeopathic medical college, receiving the degree of M.D. In 1872 he entered on the professorship of physics and chemistry in Alfred university, which position he held continuously till his death. In 1882 he took a graduate course in physics at Cornell university. In 1871 his alma mater conferred on him the degree of M.A. and in 1891 that of Ph.D.

He was a painstaking and efficient instructor and a most genial Christian gentleman. He was a member of the American association for the advancement of science, the American chemical society, the American microscopical society, and counselor of the American institute of civics.

He was the author of a *Manual of civil government.*

## Members, 1898

When the name of an institution includes the name of its town or city, the latter is not given
Where no state abbreviation appears, New York is to be understood.

**Allen,** Charles M., Pratt institute, Brooklyn
Allen, John G., Rochester free academy
Anderson, W. W., Wellsville
Andrews, Kate R., Rochester high school
Arey, Albert L., Rochester free academy
Armstrong, Charles H., 109 W. 54 st., New York
Atkinson, George F., Cornell university

**Babcock,** Edward S., Portville high school
Bardwell, D. L., Cortland normal school
Barrows, Franklin W., 45 Park st., Buffalo
Beach, Channing E., 49 Day's park, Buffalo
Beach, Grace B., 322 St Nicholas av., New York
Beadel, Charles W., Shamokin (Pa.) high school
Bennett, R. Grant, Locust Valley
Benoliel, Sol D., 206 Washington park, Brooklyn
Bevier, Marie L., 106 W. 61 st., New York
Bickmore, Mary E., 30 W. 128 st., New York
Bishop, Irving P., Buffalo normal school
Blackall, Gertrude C., Wilder building, Rochester
Blossom, Margaret, 440 Henry st., Brooklyn
Bogart, Marston C., Columbia university
Bond, W. E., Potsdam normal school
Boniface, Sister M., Nazareth academy, Rochester
Bowers, Emma, 100 Hector st., Ithaca
Brace, Edith M., 40 Courtland st., Rochester
Bradley, Theodore J., Albany academy

Brigham, A. P., Colgate university
Bristol, Charles L., New York university
Brownell, W. A., Syracuse high school
Burgin, Bryan O., Lowville academy

**Caldwell,** G. C., Cornell university
Call, R. Ellsworth, Children's museum, Brooklyn
Carpenter, Idelette, Maplewood, N. J.
Carss, Elizabeth, Teachers college
Cattell, J. McKeen, Garrison-on-Hudson
Chambers, V. J., Geneva high school
Chollar, Sarah V., Potsdam normal school
Clapp, B. G., Fulton high school
Clark, John Anson, Ithaca high school
Clark, O. D., Boys high school, Brooklyn
Clark, Tracy E., 102 Macon st., Brooklyn
Clarke, John M., Polytechnic institute, Troy
Clement, Arthur J., Regents office, Albany
Cobb, Charles N., Regents office, Albany
Comstock, J. H., Cornell university
Cooley, LeRoy C., Vassar college
Cornish, R. H., Girls high school, 36 E. 12 st., New York
Curry (Miss) C. M., Cortland normal school
Curry (Mrs) Sarah E., 70 N. Main st., Cortland
Curtis, Arthur M., Oneonta normal school

**Dann,** Mary E., 413 Clinton st., Brooklyn
Davenport, Charles B., 11 Francis av., Cambridge, Mass.
Dean, Philip R., 60 W. 13 st., New York
Denham, Henry H., 142 N. Pearl st., Buffalo
DeShon, Charles H., 646 Elm st., Buffalo
Dodge, Charles W., University of Rochester
Dodge, Richard E., Teachers college
Doll, Carrie L., 587 Ellicott st., Buffalo
Doremus, C. A., 59 W. 57 st., New York
Doubleday (Mrs) N. DeG., care of Doubleday & McClure publishing co., New York

**Elliott,** Arthur H., New Rochelle
Emerson, Josephine, Pratt institute, Brooklyn

**Fleming,** Mary A., 432 Pearl st., Buffalo
Fox, Ada H., Masten park high school, Buffalo
Freley, J. W., Wells college
Furman, Bertha M., 69 W. 71 st., New York

**Gage,** Simon H., Cornell university
Gaines, (Miss) E. V., Adelphi academy, Brooklyn
Gardner, George S., Marion collegiate institute

**ibson**, J. J., Montclair, N. J.
illmore, Gertrude, 49 Garden place, Brooklyn
oodrich, A. L., Utica academy
orton, J. Irving, 22 Dale av., Sing Sing
raham, W., Syracuse university
reene, W. J., Lewiston
reenwood, John W., Buffalo normal school
riffis, Henry L., New Paltz normal school

**aanel**, Eugene, Syracuse university
allock, William, Columbia university
argitt, Charles W., Syracuse university
arper, Charles A., Columbia university
arris, S. G., Baldwinsville academy
ering, D. W., New York university
ixon, Kate B., 24 E. 128 st., New York
odges, G. C., 129 John st., Utica
opping, Roy, 5 Dey st., New York
oxie, Jane L., 109 W. 54 st., New York
ubbard, Dwight L., 117 W. 93 st., New York
udson, George H., Plattsburg normal school
umphrey, O. D., Jamaica, N. Y.
unt, Arthur E., Manual training high school, Brooklyn
urd, Frances, Oneonta normal school
yde, F. S., 215 Schermerhorn st., Brooklyn

**ameson**, J. M., Pratt institute, Brooklyn
aquish, Benjamin M., 204 W. 106 st., New York
ewett, Franklin N., Fredonia normal school
ouet, C. H., Roselle, N. J.

**auffman**, W. L., Yonkers high school
elly (Mrs) H. A., 669 Madison av., New York
elly, H. A., 109 W. 54 st., New York
emp, James F., Columbia university
enyon, O. C., 110 Lancaster av., Syracuse
ingsbury, George H., Elmhurst high school
napp, Allen H., Canton high school

**angworthy**, William F., Colgate academy, Hamilton
aurence, Clara Louise, Waterville
ennon, Alice L., Brockport normal school
ennon, W. H., Brockport normal school
ewis, Fred Z., Boys high school, Brooklyn
ewis, (Mrs) Lucy S., 30 Clifton place, Brooklyn
inville, Henry R., 60 W. 13 st., New York
loyd, Francis E., Teachers college
oeb, Morris, New York university

Lovell, Thomas B., Niagara Falls high school
Lyon, Catherine E., 86 East av., Rochester
Lyon, Howard, Oneonta normal school

**Mac Claughry,** Molly, Saratoga Springs
McGreevy, Thomas, 200 Albany st., Buffalo
McKay, John S., 460 Green av., Brooklyn
McMurry, Frank M., Teachers college
Mann, Warren, Potsdam normal school
Mar, Frederick W., Boys high school, Brooklyn
Marcella, Sister M., Nazareth academy, Rochester
Matteson, Florence M., Oneonta normal school
Maury, Mytton, 109 Cascadilla, Ithaca
Mead, F. L., Madison school, Syracuse
Mercer, W. F., Chamberlain institute, Randolph
Merrill, F. J. H., New York state museum, Albany
Moler, G. S., 106 University av., Ithaca
Moore, Katherine Rowe, Dresden
Moore, V. A., New York state veterinary college, Ithaca
Morrey, William T., 107 W. 104 st., New York
Morrill, A. D., Hamilton college
Morse, H. L. F., Troy high school
Murphy, Charles T., 353 Adelphi st., Brooklyn

**Nichols,** Edward L., Cornell university

**Osborn,** Henry F., Columbia university

**Paddock,** Bertha L., Franklin academy, Malone
Palmer, Lelia B., North Bridgewater
Pattee, Ernest N., Syracuse university
Peabody, James E., 3 av. and 157 st., New York
Peck, Henry A., 307 Waverly place, Syracuse
Peckham, W. C., Adelphi college, Brooklyn
Piez, Richard K., Oswego normal school
Pingrey (Mrs) Cora E., White Plains high school
Piper, P. F., Buffalo central high school
Proper, Emberson E., Boys high school, Brooklyn
Prosser, C. S., Union university

**Quereau,** E. C., Syracuse university

**Raneson,** Edward B., 226 E 16 st., New York
Reed, Raymond C., New York state veterinary college, Ithaca
Rich, J. F., Batavia
Richards, Charles R., Teachers college
Robinson, Emma C., 419 S. First av., Mt Vernon
Rogers, F. J., Ithaca
Rogers, Mary F., Ithaca

Rollins, Frank, 356 W. 145 st., New York
Rowlee, W. W., Cornell university
Ruedemann, Rudolf, Dolgeville union school
Russell, Henry R., 542 9 st., Brooklyn

**Sage,** L. Belle, 413 Laurens st., Olean
St John, Thomas M., 352 W. 56 st., New York
Sampson, Ezra W., 178 and 3 av., New York
Sanial, Marie L., 1180 Boston av., New York
Schmitz, H. J., Geneseo normal school
Schussler, Amy, Teachers college
Scott, Charles B., Oswego normal school
Scribner, E. E., Dunkirk high school
Seymour, A. T., 3080 3 av., New York
Sharp, Clayton H., Cornell university
Shatz, Josephine, 6 Canfield place, Rochester
Shearer, John S., Cornell university
Sheldon, C. S., Oswego normal school
Sieberg, W. H. J., 138 W. 126 st., New York
Sleeper, James J., P. O. box 14, New York
Spice, Robert, 55 Irving place, Brooklyn
Sprague, Oliver A., 120 W. 46 st., New York
Stepanek, Beatrice, Canton high school
Stevens, W. Le Conte, 53 Second st., Troy
Stocker, John H., 124 Hancock st., Brooklyn
Stoller, James H., Union university
Stone, Anna J., Binghamton
Stowell, T. B., Potsdam normal school
Surface, H. A., Cornell university
Sweetland, Libbie, Dryden

**Tappan,** Frances, Oneonta normal school
Tarr, Ralph S., Cornell university
Taylor, Joseph S., Sedgewick park, Fordham Heights
Thompson, Frank F., Union university
Thurston, R. H., Cornell university
Trant, Amelia Earle, 1268 Main st., Buffalo
Turner, George M., Masten park high school, Buffalo
Tyler, A. A., Syracuse

**Underwood,** L. M., Columbia university

**Van Arsdale,** May B., Teachers college
Vogt, Frederick A., Buffalo central high school
Von Nardroff, C. R., Erasmus Hall high school, Brooklyn
Vosburgh, Charles H., Jamaica, L. I.
Vulté, H. T., Columbia university

**Ward,** Charles H., Ward's natural science establishment, Rochester
Ward, Delancey W., New York dental school, New York
Watts, Oliver P., Franklin academy, Malone
Weed, Henry T., Manual training high school, Brooklyn
Wetmore, Edward W., State normal college, Albany
Wetmore, Katherine S., 108 S. Fitzhugh st., Rochester
Wheelock, Charles F., Regents office, Albany
White, T. G., Columbia university
Whitney, E. R., Binghamton high school
Wilcox, C. C., Starkey seminary, Eddytown
Wilder, Burt G., Cornell university
Williston, Arthur L., Pratt institute, Brooklyn
Wilson, John D., Putnam school, Syracuse
Wilson, Victor T., Ithaca
Woodhull, John F., Teachers college
Woodland, J. E., Cook academy, Montour Falls
Wyckoff, Adelaide E., 358 Hanson place, Brooklyn

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**Lloyd**, F. E., on study of botany, $549^7$–$50^2$.

Low, Pres. Seth, resolution of thanks to, $454^8$; address of welcome, $456^1$–$57^8$.

**McMurry**, F. M., on study of botany, $550^2$.

Meteorology, study, $554^5$; works on, $497^7$–$98^1$.

Microscope, use in secondary schools, paper and discussion, $609^9$–$18^4$.

Morrill, A. D., on training in observational science, $549^8$.

**Narcotics**, methods of teaching effects of, $453^6$, $618^8$–$19^4$.

Nature, appreciation of, $461^1$.

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Necrology report, $634^8$–$35^8$.

*New York school journal*, resolution of thanks to, $454^2$.

*New York teachers magazine*, papers printed in, $552^3$.

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Nominations, report of committee on, $454^6$.

**Peabody**, J. E., on study of zoology, $469^9$–$71^2$; Physiology in the high school, $552^8$.

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University of the State of New York

# igh School Department

**Bulletin 7 April 1900**

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## ew York State Science Teachers Association

## EEDINGS OF THE FOURTH ANNUAL CONFERENCE

**Held at Syracuse university, Syracuse, 28-29 December 1899**

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1900

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## University of the State of New York

### REGENTS

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1874 Anson Judd Upson L.H.D. D.D. LL.D. *Chancellor*, Glens Falls
1892 William Croswell Doane D.D. LL.D. *Vice-Chancellor*, Albany
1873 Martin I. Townsend M.A. LL.D. – – Troy
1877 Chauncey M. Depew LL.D. – – – – New York
1877 Charles E. Fitch LL.B. M.A. L.H.D. – Rochester
1877 Orris H. Warren D.D. – – – – – Syracuse
1878 Whitelaw Reid LL.D. – – – – New York
1881 William H. Watson M.A. M.D. – – – Utica
1881 Henry E. Turner – – – – – – Lowville
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1885 Hamilton Harris Ph.D. LL.D. – – – Albany
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1888 Carroll E. Smith LL.D. – – – – Syracuse
1890 Pliny T. Sexton LL.D. – – – – – Palmyra
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1893 Lewis A. Stimson B.A. M.D. – – – – New York
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1897 Chester S. Lord M.A. LL.D. – – – Brooklyn
1897 Timothy L. Woodruff M.A. Lieutenant-Governor, ex officio
1899 Theodore Roosevelt B.A. LL.D. Governor, ex officio
1899 John T. McDonough LL.B. LL.D. Secretary of State, ex officio
1900 Thomas A. Hendrick M.A. – – – Rochester

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### SECRETARY

Elected by regents

1900 James Russell Parsons jr M.A.

### DIRECTORS OF DEPARTMENTS

1888 Melvil Dewey M.A. *State library and Home education*
1890 James Russell Parsons jr M.A. *Administrative, College and High school dep'ts*
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University of the State of New York

# High School Department

Bulletin 7 May 1900

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## New York State Science Teachers Association

## PROCEEDINGS OF THE FOURTH ANNUAL CONFERENCE

**Held at Syracuse university, Syracuse, 28-29 December 1899**

### SUMMARY OF SESSIONS

**Thursday, 28 December, 9.30 a. m.**

Meeting of executive council

Registration

Opening session; called to order by Prof. Charles W. Hargitt, *chairman*

Address of welcome
  Dean Albert Leonard, Syracuse university

Response
  Prof. Charles W. Hargitt, Syracuse university, retiring president of the association

Introduction by Prof. C. W. Hargitt, of Pres.-elect LeRoy C. Cooley, Vassar college

Remarks
  Prof. LeRoy C. Cooley

Sequence of sciences in the secondary school curriculum
  Prin. T. B. Stowell, Potsdam normal school

Prof. JOHN F. WOODHULL, Teachers college, New York (read by J. E. Peabody)
J. E. PEABODY, Boys and girls high school, New York
Prof. W. F. LANGWORTHY, Colgate academy

**Thursday, 2 p. m.**

Section meetings

Section A—Biology. Prof. C. W. DODGE, University of Rochester, *chairman*

Report of subcommittee on zoology
Presented by Prof. C. W. DODGE

Minority report
Presented by J. E. PEABODY, Boys and girls high school, New York

Discussion
Prof. H. R. LINVILLE, Boys high school, New York
Prof. C. W. DODGE, University of Rochester
Prof. C. W. HARGITT, Syracuse university
Prin. E. J. MANLY, Middleport high school
Prof. J. H. STOLLER, Union university
Inspector A. G. CLEMENT, University of the State of New York
Prof. S. H. GAGE, Cornell university
Prof. H. A. SURFACE, Cornell university
Prof. A. D. MORRILL, Hamilton college
Prof. P. A. FISH, Cornell university.
Dr H. L. TAYLOR, University of the State of New York

Section B — Chemistry and physics. Prof. E. W. WETMORE, State normal college, *chairman*

Report of subcommittee on chemistry
Presented by Prof. E. W. WETMORE

Discussion
Prof. R. H. CORNISH, Girls high school, New York
Prin. T. B. STOWELL, Potsdam normal school

Prof. A. L. Arey, Rochester high school
Prof. H. J. Schmitz, Geneseo normal school
Prof. E. W. Wetmore, State normal college
Prof. I. P. Bishop, Buffalo normal school
Prof. W. H. Snyder. Worcester (Mass.) academy
Prof. E. S. Babcock, Alfred university
Prof. W. A. Brownell, Syracuse high school
Prof. E. L. Nichols, Cornell university
Mrs C. E. Pingrey, Whiteplains high school
Prof. L. C. Cooley, Vassar college

Report of subcommittee on physics
Presented by Prof. A. L. Arey, Rochester high school

Discussion
Prof. G. M. Turner, Masten Park high school, Buffalo
Prin. C. M. Bean, Pulaski academy
Prof. E. W. Wetmore, State normal college
Prof. E. L. Nichols, Cornell university
Prof. O. C. Kenyon, Syracuse high school
Prof. H. L. F. Morse, Troy high school
Prin. T. B. Lovell, Niagara Falls high school
Inspector C. N. Cobb, University of the State of New York
Prof. I. P. Bishop, Buffalo normal school
Prin. C. W. Richards, Oswego high school
Mrs C. E. Pingrey, Whiteplains high school
Prof. R. J. Kittredge, Schenectady
Prin. H. T. Skerritt, Camden high school
Dr H. L. Taylor, University of the State of New York
Prin. B. G. Clapp, Fulton high school
Prof. E. S. Babcock, Alfred university
Prof. A. L. Arey, Rochester high school

### Thursday, 8 p. m.

nnual address: Science for education
Prof. LeRoy C. Cooley, Vassar college

eception by Syracuse university, in University block

**Friday, 29 December, 9.45 a. m.**

Earth science in secondary schools

Prof. W. H. Snyder, Worcester (Mass.) academy

Discussion

Prof. R. H. Cornish, Girls high school, New York

Prin. T. B. Lovell, Niagara Falls high school

College entrance requirements in science

Dean W. H. Crawshaw, Colgate university

Discussion

Prof. A. D. Morrill, Hamilton college

Edith M. Brace, University of Rochester

Prof. S. H. Gage, Cornell university

Prof. William Hallock, Columbia university

Prof. C. W. Hargitt, Syracuse university

Prof. A. T. Seymour, Boys and girls high school, New York

Prof. E. N. Pattee, Syracuse university

Prof. W. D. Merrell, University of Rochester

Dean W. H. Crawshaw, Colgate university

Training of science teachers for secondary schools

Prof. E. L. Nichols, Cornell university

Discussion

Prof. William Hallock, Columbia university

Prof. E. W. Wetmore, State normal college

J. E. Peabody, Boys and girls high school, New York

**Friday, 2.15 p. m.**

Section meetings

Section A— Biology. Inspector A. G. Clement, University of the State of New York, *chairman*

Equipment of the secondary school laboratory

Inspector A. G. Clement, University of the State of New York

Management of laboratory classes
    Prof. G. F. Atkinson, Cornell university
    Prin. C. W. Richards, Oswego high school
  Discussion
    Inspector E. W. Lyttle, University of the State of New York
    Miss L. B. Palmer, Utica free academy
    Prof. H. A. Surface, Cornell university
    Inspector A. G. Clement, University of the State of New York
    Prof. C. W. Dodge, University of Rochester
    Prof. F. W. Barrows, Buffalo central high school
    Prof. C. G. Rogers, Syracuse university
    Prof. W. D. Merrell, University of Rochester
    Dr E. J. Durand, Cornell university
    Prof. H. M. Pollock, Albany high school

ection B — Physics and chemistry. Prof. E. R. Whitney, Binghamton high school, *chairman*

Equipment of the secondary school laboratory
    Prof. E. R. Whitney, Binghamton high school
Management of laboratory classes in chemistry
    Prof. A. L. Arey, Rochester high school
  Discussion
    Prof. G. M. Turner, Masten Park high school, Buffalo
    Prof. W. A. Brownell, Syracuse high school
    Prof. E. R. Whitney, Binghamton high school
    Prof. I. P. Bishop, Buffalo normal school
    Prof. W. M. Bennett, Erie Pa.
    Prof. William Hallock, Columbia university
    Prof. W. J. Hancock, Erasmus Hall high school, Brooklyn
Management of laboratory classes in physics
    Prof. Frank Rollins, Boys high school, New York

ection C — Earth science. Prof. R. H. Cornish, Girls high school, New York, *chairman*

Management of laboratory classes

Prof. W. H. Snyder, Worcester (Mass.) academy

Discussion

Prof. C. Stuart Gager, State normal college

Prof. W. A. Brownell, Syracuse high school

Prof. Frank Carney, Keuka college

Prof. G. S. Gardner, Rochester

Prof. H. A. Surface, Cornell university

Exhibition of plans and apparatus

Prof. R. H. Cornish, Girls high school, New York

**Friday, 3.30 p. m.**

General session

Report of the committee of nine

Presented by Prof. LeRoy C. Cooley, Vassar college

Report of the committee on alcohol and narcotics

Presented by Prof. I. P. Bishop, Buffalo normal school

Miscellaneous

Prof. I. P. Bishop, Buffalo normal school

Prof. H. A. Surface, Cornell university

Prof. S. H. Gage, Cornell university

*Adjourned at 5 p. m.*

## SUMMARY OF ACTION

### Committee reports

*Voted,* That the report of the committee of nine be adopted and that the committee be discharged with the thanks of the association.

**Resolutions.** The committee on resolutions presented the following report, which was unanimously adopted.

*Whereas,* The regents of the University of the State of New York have shown sincere interest in and appreciation of the work of this association, specially in the publication of the reports of its meetings:

*Resolved,* That the thanks of the association be given to the regents, as well for what they have done in the past as for what it is hoped they will do in the future.

*Resolved,* That we, as members of the New York state science teachers association, extend our hearty thanks to Syracuse university, through its officers, for the cordial reception which it has extended to us in placing the university building and equipment at our disposal, and for its cooperation in the work of the association.

FRANKLIN W. BARROWS, *chairman*
A. D. MORRILL
WILLIAM HALLOCK

**Nominations.** The committee presented the following names:
*President,* Charles Wright Dodge, University of Rochester
*Vice-president,* Albert P. Brigham, Colgate university
*Secretary and treasurer,* O. C. Kenyon, Syracuse high school
*Council*
1901 J. H. Stoller, Union university
1902 E. R. Whitney, Binghamton high school
1903 A. D. Morrill, Hamilton college
1903 E. W. Wetmore, State normal college
1903 H. R. Linville, Boys high school, New York

I. P. BISHOP, *chairman*

By vote of the association the secretary was directed to cast a ballot for the nominees as reported, and they were declared elected for the ensuing year.

### Treasurer's report

The treasurer presented the following report for the year ending 29 Dec. 1899:

| *Receipts* | |
|---|---|
| Balance in treasury | $110 57 |
| Annual dues | 126 |
| | $236 57 |

*Expenditures*

| | | |
|---|---|---|
| W. B. Whitney, printer | $18 | |
| William & Robert Maar, printers | 3 | |
| Sec. F. W. Barrows, bills of 1898 | 12 06 | |
| Postage | 11 80 | |
| Express and telegrams | 2 55 | |
| Clerical work | 14 50 | |
| LeRoy C. Cooley, for committee of nine | 19 | |
| C. W. Hargitt, for local committee | 6 35 | |
| Sec. H. C. Bumpus, American association of naturalists | 4 80 | |
| Trunk line association | 6 | |
| Exchange on checks | 22 | |
| | | $98 28 |

Balance in treasury, 29 Dec. 1899.......... $138 29

JAMES E. PEABODY, *treasurer*

### Report of auditing committee

We have examined the accounts of the treasurer of the association and find them to be correct to date.

CHARLES WRIGHT DODGE, *chairman*
E. R. WHITNEY

### Committee on alcohol and narcotics

The committee of five appointed in 1898 to ascertain and report what is definitely known regarding the physiologic effects of alcohol and narcotics on the human system, announced that it was not yet prepared to make a report on this subject.

The committee was continued for another year.

### Communications

Prof. Arey read a letter from the secretary of the American chemical society.

A motion was made that the communication be received and placed on file.

On recommendation of Inspector Cobb that it would be a good plan to appoint a committee of one consisting of the chairman of the just dissolved committee of nine, to communicate the work which the committee has performed on the lines suggested in the letter, which can probably be done by transmitting the report it was,

*Voted,* That the chairman of the committee of nine be appointed such a committee.

**Meeting of 1900.** It was announced that the next place of meeting would be Rochester, the time to be determined later by the executive committee.

## ADDRESSES, PAPERS AND DISCUSSIONS

### Thursday morning, 28 December

**Prof. C. W. Hargitt** — It is my pleasant duty to call the association to order under these auspices and to introduce Dean Albert Leonard of the college of liberal arts, Syracuse university, who will extend to the association a few words of welcome.

**Dean Albert Leonard** — On behalf of Syracuse university, it is my privilege and my pleasure on this occasion to extend to this association a word of greeting and a word of welcome. Syracuse university, I need not say, is in hearty sympathy with the spirit and the purpose of this organization and gives to this body of teachers a most cordial welcome to this place. We put at your service our halls and laboratories and shall leave nothing undone to promote the success of this year's meeting. Representing as it does the highest intelligence, scholarship and professional zeal of school and college, this association is sure to exert a far-reaching influence for good on the educational thought and practice of the state, and no teacher in school or college who has not reached the most hopeless stage of arrested development can be indifferent to the spirit and purpose of an organization like the New York state science teachers association.

And there is work enough for this association to do. While we all rejoice in the progress toward better things in education that has been made during the past decade or so, yet every true teacher recognizes the fact that the art of teaching is susceptible of unlimited growth and advancement, and that there is much to be done before the pedagogic art can be said in any sense to have reached a fair degree of perfection. In spite of the great activity in the professional aspects of teaching, there are still more teachers in school and college who are indifferent to education as a science than the cause of sound education and correct teaching permits. In spite of the increased activity in educational circles, the number of teachers in school and college who take a genuine and intelligent interest in education for its own sake is not large. The relation of many teachers in both school and college, it has been well said, to the science of education is just that of the motorman to the trolley car. They use it, but of its nature, its principles and processes, they are profoundly ignorant; and, in seeking to overcome this professional inertia, this indifference to the nature and the processes of sound education, this association will accomplish the most lasting good.

This I take to be one of the avowed objects of the association, for an examination of the program of this year's meeting discloses the recognition of the vitally important pedagogic truth that the aim and the method of the teaching process must be clearly apprehended by the successful teacher. We are beginning to understand, as never before, the fact that the teacher must understand not simply how a subject should be taught, but why it should be taught and how much of it should be taught. And therefore it seems to me that in laying stress on the educational value of the sciences in our school and college courses this association can exert its most potent influence. The attitude of every teacher toward his work is determined by the end in view, and his attitude toward his pupils is determined by a conscious recognition of just what value a subject will be to the intellect and the soul of the student.

I am specially gratified therefore to note that, in the program for this meeting, so much stress is put on the educational value of the different sciences in school and college courses. Scientific men are apt to lay stress, and rightly too, on the fact that the end of science teaching is not the acquisition of knowledge, not the learning of facts; and yet, if I may be presumptuous enough to say it, I believe the greatest mistake that science teachers make is after all in laying more stress on the content of the sciences than on the method and processes of teaching. You all know better than I do that the end of science teaching is not knowledge but the knowledge-loving spirit. It is not simply intellectual discipline that should be sought, but the scientific attitude of mind, and this result I need not say to this body of teachers can be obtained only when we clearly recognize the processes and the principles of sound mental growth.

I am specially pleased also to find in the program a recognition of the fact that there is still something to be done in the matter of college entrance requirements. Those who teach in the secondary schools of the state know that there are as many standards of entrance requirements as there are colleges in the state; in truth, it may be said that there are more standards than colleges, for some colleges have two standards — the one published in the catalogue and the one that is not. Under existing conditions, it is practically impossible for secondary schools at present to do the best work, and this unsatisfactory condition will continue till we have something like a uniform standard of college entrance requirements. I therefore commend as one important topic for your deliberation an attempt to modify and to unify in some respects the present diverse standards of college entrance requirements.

But I was asked to make only a few introductory remarks at this time, and I fear that unless I conclude at this point I may make a speech; therefore I close with the hope that this will be a meeting of great pleasure and profit to all who are here, and that the discussions of this body of teachers will result in great profit to the schools and colleges of the state. The high ideals that govern the deliberations of this association will certainly lead us all to invest our teaching with a sublimer import.

**Prof. C. W. Hargitt** — From observations and experiences in the work of this association in former years, I think I may with some measure of confidence respond to this very thoughtful and suggestive address of welcome by saying that we trust that there may be ample justification in the work of the present meeting for the good things which the address has predicted to us, and that, moreover, we believe the work of former years has been contributory to the standards and objects which the speaker has forcefully brought to our attention. On behalf of the association, I beg to express to Dean Leonard the assurance that it shall be our object to attain so far as lies within our power to these ideals of scientific possibility and pedagogic skill. There is yet much to be accomplished before we can hope to enter into the full realization of these aims. That some advance has already been made however, and that the signs of the times are ominous of progress, we confidently believe. Therefore, with an abiding faith in the method and spirit of science, and in its growing necessity in education, we take up the duties of the present occasion with courage and enthusiasm.

Not to multiply words, I desire in conclusion, on my own account, to express to the association hearty thanks for the courtesies which I have had at the hands of the members, and my appreciation of the honor extended to me in the office whose duties it has been my pleasure and effort to discharge during the past year. It now becomes my pleasure and honor to introduce to the association, and to all present, the president-elect, Prof. LeRoy C. Cooley of Vassar college.

**Prof. LeRoy C. Cooley** — I feel that I must not delay the good things in store for us, as promised by our program, by many preliminary words of my own, but there are one or two things which I can not refrain from saying. First of all I wish to assure the association of my profound appreciation of the honor it conferred on me by an election to the highest office in its gift. When I remembered the achievements of the association in past meetings, I did not at all approve your choice, but, happily for me, the fame and the influence of the association do not depend wholly on its president; they rest in large degree with the members, and have become so great under the brilliant leadership of my predecessors that the momentum already gained may be sufficient to carry the association safely over a weak place in the administration of its affairs.

Your attention has just now been called to the fact that this association is devoted chiefly to pedagogic questions relating to science teaching. Many of these important matters are still unsettled, and so long as they remain in that condition, it seems to me that the association will be compelled to devote itself to them. But I look forward to the time when the hope expressed by the second president of the association will become a reality; when this association shall prove to be a powerful agent for the promotion of science teaching, not only by insuring the contact of science teachers with the best educational thought, but also by keeping them in touch with current scientific research and acquainted with the trend of thought in the progress of pure science itself. But our program for this occasion, as hitherto, is devoted to fundamental and important problems relating to the use of science for education.

## SEQUENCE OF SCIENCES IN THE SECONDARY SCHOOL CURRICULUM

BY PRIN. T. B. STOWELL, POTSDAM NORMAL SCHOOL

A course of studies must be surveyed from the end to which it is directed before its relevancy can be comprehended. Each study has its special value and also a common element which gives it generic value. It may be introduced into the curriculum for specific or for generic ends.

I notice first that the sciences are classed by themselves not on account of subject-matter so much as because of the mode of procedure pursued in their study. Thus history or literature may be examined as scientifically as the nature studies and in this sense is science.

Two ends should be kept in mind in fixing a course of study:

1 The value of the matter itself as an end;

2 The kind of activity aroused by the study, that is the habits, tastes and ability acquired, the power gained.

There is almost a consensus among school men that present experience, which is the sum total of the past, is that which gives meaning to, hence value to the future. The new becomes intelligible in terms of the old, which means that primary or first knowledge must be sensuous. If this truth be admitted, we are forced to the conclusion that the sciences should have a place near the beginning of the curriculum. I am not now contending for the utilitarian aspect of the question, for I can not admit that the study of the sciences is barren of culture, that the peculiar *esprit* inculcated by the study of literature and of history can not be fostered by study of the sciences. I am simply holding to a law of mind; trying to emphasize the necessity of grounding culture on sensuous knowledge or observation knowledge.

To attack our problem directly, we observe

First, the agreement of all the sciences in that they are observation studies. That which we have seen, that which we have heard, that which we have handled, declare we unto you. If the sciences are investigated through textbooks only, they become poor literature and yield meager results in matter attained and power developed.

Second, each science has its distinctive character and calls for specific treatment.

The properties of matter — constituting mechanics or dynamics and statics — are preeminently observational and address more senses than one. Acoustics, optics, thermics and electricity are as fundamentally observational; but early in their pursuit the student is called on to use subjective data rather than objective as the basis of his investigation. As soon as the real science or the explanation of phenomena is begun, observation ceases. When definite, clear, positive experience is attained, the objective stimulus has done its work and should be removed. A science which does not rapidly progress beyond the sensuous fails in attaining its maximum valence.

The writer's position regarding physics will be readily divined. Its basal facts are observational, its principles or laws are psychical. The real value of the study, I apprehend, is to be sought in the condition in which the self, the ego, is left.

Chemists even may differ as to what is chemistry. Laboratory experimentation, which is observational and fundamental, should not be confounded with chemistry, which as a science is wholly subjective. The exactness of the subject, its highest educating value, lies not in the observation but in the inference which the experimentation justifies. Some of the experiments of chemistry are simpler than most of the experiments of physics. Thus a few test-tubes, corks, glass tubing and a lamp will permit the demonstration of most of the qualitative work which is the basis of chemistry; but this forms so meager a part of the possibilities of the study that, during more than a score of years in the chemical laboratory, I have looked on experimentation as a small item in determining the valence of the study.

The study of the biology group is predicated on observation. Generalization, classification, etc. follow as in the subjects already discussed. Since then, there is agreement among the biologic sciences in method or procedure determined by the nature of mind, I conclude that the order of their sequence can not be determined by psychology.

Since the interdependence of subject-matter, with the possible exceptions of astronomy and the earth group, does not fix sequence, I conclude that the sequence of the biology group must be determined by utilitarian or prudential considerations, or expedience. From the utilitarian view it may be argued that no group of studies has more direct reference to the phenonema of life than the biology group when studied with reference to man as the final cause. The argument is so self-supporting that farther elucidation seems unnecessary. The difficulties of manipulation, the outfit, the cost of material for study, etc. are no greater than those attending the study of any other group. It is the judgment of the writer that the biology group should come early in the course. The details of the subject, the coordination of botany, zoology and physiology, are not within the scope of this paper.

From the prudential view, much will depend on the personality of the teacher and the equipment of the school. The writer is convinced that the laboratory outfit for teaching general chemistry and qualitative analysis is cheaper and is more easily manipulated than the apparatus in physics; hence he would suggest that chemistry precede physics.

The position of the earth group — physical geography, mineralogy and geology — seems to be one of dependence, indicating that these should follow botany, zoology, chemistry and physics. Astronomy should evidently follow plane geometry, chemistry and physics but its relation to the earth group is not so plainly indicated. As already pointed out, the work should be largely laboratory, and as soon as practicable it should be exclusively so.

With the purpose of partially eliminating the personal equation from the conclusion reached, letters were addressed to four classes of teachers, asking for the results of experience and observation regarding the sequence of the sciences. Biologists, physicists, chemists, general science teachers and heads of schools were consulted.

I note:

1 That there is unanimity of judgment regarding the character of instruction, and the desirability that laboratory work be required.

2 Agreement as to the nature of mental activity involved and the order of dependence.

3 Agreement as to the intellectual and ethic culture attained.

4 That no teacher gives prominence to his own department, each is willing that initiatory work shall be done by another.

5 There seems to be a strong desire to have what might be denominated a "spiral arrangement," beginning with elementary lessons, and passing through the three groups, and then returning for *intensive* work, with possible eliminations. However there is equal doubt as to the practicability of such a course under present conditions.

6 There is a general consensus as to the position of the earth group (physical geography and geology); that these should come last.

7 More would begin with chemistry than with physics.

8 More would begin with the biology group than with the physical group. There is a very satisfactory consensus that botany and zoology should be correlated as biologic studies with special reference to man.

The writer is convinced that a working consensus can be secured by free discussion of a practical order of sequence.

I desire to acknowledge my indebtedness to the teachers, who without exception responded to the request for aid in preparing this paper. The list is subjoined to show the scope of the inquiry.

Alice H. Albre, Fredonia normal school
W. M. Booth, Cortland normal school
Dr Franklin W. Barrows, University of Buffalo
Sup't Darwin L. Bardwell, Binghamton
I. P. Bishop, Buffalo normal school
Sarah V. Chollar, Potsdam normal school
Charles N. Cobb, University of the State of New York
Dr LeRoy C. Cooley, Vassar college
Dr J. McK. Cattell, Columbia university
Dr J. H. Comstock, Cornell university
Mary E. Dann, Girls high school, Brooklyn
Dr William Hallock, Columbia university

Dr Charles W. Hargitt, Syracuse university
W. Franklin N. Jewett, Fredonia normal school
W. H. Lennon, Brockport normal school
Dr C. H. Leete, Dr Sach's school for girls, New York
Warren Mann, Potsdam normal school
Pres. W. J. Milne, State normal college
A. F. Onderdonk, Albany high school
William C. Peckham, Adelphi college
James E. Peabody, Boys and girls high school, New York
Dr H. J. Schmitz, Geneseo normal school
E. W. Wetmore, State normal college
E. R. Whitney, Binghamton high school
Dr Burt G. Wilder, Cornell university
Dr John Woodhull, Teachers college, New York

What is meant by apperception if not the knowledge gained from a mass of experiences or truths? An apperception can not be derived from two or three facts, in literature, history or science, in subjective or in objective study: there must be a mass of experiences. Therefore for the basis of the school curriculum I contend for facts. Call this utilitarian or by any name you please. This thought carried to its ultimate analysis means that the basis of all knowledge is sensuous. From the argument given, the sequence of studies must be determined by either utilitarian considerations or prudential. The fact just referred to, that the biology group has reference to man as its end, is so self-supporting that argument seems unnecessary.

May I digress a moment to introduce my idea of studying botany and zoology together as cell function, so that whatever is learned in botany shall assist and emphasize what is learned in zoology, and conversely. Intensive study, quantity, is the royal road to quality. Hammer the truth of *cell function* from the vegetal kingdom and from the animal kingdom and you will ultimately drive into the soul of the pupil the idea of function and of life. I am not particular whether botany and zoology are studied as separate studies for a specified time, or whether they are studied together and are called biology — the name does not disturb me, but get at the thought of function and its relation to structure.

There is much to be said from the theoretic standpoint about the necessity of knowledge of chemistry to understanding human physiology; I know that I do not declare the judgment of many present, when I say that knowledge of chemistry throws little light on cell function. I can perform experiments to show the effect of carbonic acid gas on respiration, and can show how starch may be converted into sugar, but such is not real knowledge of chemistry as a science; it is illustrative rather than educative. Can you work out the reaction of the pancreatic fluid on the fats? Can you give the chemical reaction of bile? I may demonstrate how starch becomes sugar but the agent that does the work is not the blackboard. The process is a complex bioplasmic one, and there is an element in it that eludes me; call it spirit, life, the unknown or anything you please. I can not show just how it is that, when I turn the horse and the cow and the pig and the sheep into clover, the clover appears as different kinds of bioplasm, horseflesh, beef, pork and mutton; I can not work out the reaction, I have never seen the equation. I am not sure that a knowledge of chemistry is really essential to an intelligent study of biology. Possibly some one here can explain why a current of electricity affects the *nucleus* in a manner differing from that in which it affects the *formative* or the *formed* matter. I know that, when I apply the electrodes to a muscle or prick it with a pin, I am acting in the realm of physics, for I have impact; but a knowledge of physics does not throw light on the process named. I have seen many a fellow who could drive a nail better than I, who never heard of the laws of impact. My knowledge of physics does not tell me how to stimulate a muscle, and I never think of the "difference of potential" when I am stimulating the convolutions of the brain. It is not a question of electricity; I am concerned in another problem, into which my knowledge of physics does not enter. Thus, while you may theoretically argue that a knowledge of physics and chemistry throws light on the study of biology and the work of the biologic laboratory, practically I never could discover that they were of assistance to me, and therefore I have not argued that they should precede the study of biology. I have argued in favor of putting biology early in the course from prudential reasons as well as utilitarian. The law requires physiology in the first year of the high school; why not then make this study intelligent and intelligible by putting the whole of the biologic group in the first year?

**Prof. John F. Woodhull** — Since the committee of ten of the National educational association issued its report in 1892 on studies in secondary schools, it has been very much the fashion to discuss courses of study. It would appear however that, while teachers of other subjects have organized and discussed, prepared definite plans and carried them into execution, the teacher of science has been contented to do his work as an individual, heroically it may be, but alone. Hence there is no settled practice as to the sequence of the various subjects in science and little or no attempt at relating them either to one another or to other subjects in the curriculum; no uniformity in opinions as to what the courses in the various sciences should constitute, or what their aim should be.

In discussing this question I shall give more weight to the needs of the pupil than to the individual preference of teachers or to the logical arrangement of subjects. Let us, however, ask whether these considerations are antagonistic to one another.

In logical sequence, the physical sciences come first, and biology and geography follow. This order is required both by the subject-matter and the method.

First, as to method. The study of science requires the use of the laboratory method. During the first few months of high school work in science, pupils should be specially trained in good laboratory habits, and pupils in the early part of the high school course are at the right age — about 13 to 15 years — to begin to learn the mechanical side of laboratory work. For this purpose I would have chemistry in the first year, followed by physics in the second year. It is possible to put nearly all the chemical apparatus in the hands of each pupil. Test-tubes, beakers and flasks constitute most of this equipment, and need not cost more than $2 or $3 a pupil. This is not true of physics. No one expects to have physical apparatus enough to supply each member of his class with every piece; hence the pupil in physical laboratory work must be a little more capable of self-direction. The mechanical part of laboratory work in chemistry may, and I believe should, be simpler than that of physics. When the experiments are going badly in the laboratory, as they frequently will with beginners, the teacher should perform an experiment in the presence of the class, discussing the difficulties as he proceeds, and when he has finished, have all try the same experiment. In this manner he trains the pupils to do things as they ought to be done and to see things as they are. I should first teach them to bend a delivery tube that approaches pretty closely some model taken as a standard. I should train them to transfer powders to test-tubes without getting any on the tables, or even on the sides of the tubes; to invert a bottle of water for catching gases without admitting any air; to heat test-tubes and flasks without breaking them; to use acids without spotting the tables or the clothing or the labels on the bottles; to generate chlorin, hydrogen sulfid, etc. without contaminating the air of the room. If they are not so trained when quite young, they are hopeless. An old student can not be trained to become a good surgeon; he will let the bacteria in somewhere. The college professor who gets hold of a lot of careless students finds that he is quite helpless. He can do very little toward reforming their laboratory habits. Indeed, while the first high school class will submit very willingly to this instruction in painstaking, careful habits, the third and fourth year pupils are already getting beyond that stage.

Next, as to subject-matter. I put chemistry before physics, not only because it enables me better to introduce young people to laboratory methods so far as the mechanics of these go, but also because it may, and I believe it should, be treated as a simpler subject than physics with reference to training in thought power. High school textbooks in chemistry as a rule are not so difficult as high school textbooks in physics. It is true that portions of the books in both subjects are not understood by the pupils. Most of the chemistry however which the first year high school pupils do not comprehend will be incomprehensible to the fourth year high school pupils likewise, and this may properly be left for the college course. Chemical theory has very little place in the high school in whatever year the subject is taught. We may treat the subject so that *combustion* in chemistry shall be simpler than *heat* in physics; the *chemistry of water* simpler than the *mechanics of fluids;* the chemical conduct of chlorin, sulfur, nitrogen, carbon, etc., a simpler subject of study than electricity and sound. I find that chemistry lends itself very readily to the training of pupils 13 or 14 years of age, not only in the mechanics of the laboratory, but also in the more important process of making experiments lead to orderly thought. Pupils of that age can be readily taught all the chemistry necessary to fit for college, so that we need not be hampered by that consideration. This I have done continuously for the last 10 years. The work is certainly no more difficult than the algebra which they are taking the same year. I regard chemistry as the key to all the sciences in the high school curriculum.

Physical science, including chemistry and physics, furnishes the proper foundation for the study of biology and geography in respect both to method and to subject-matter. Neither biology nor geography furnishes such good opportunities for training in the mechanics of the laboratory, nor do they furnish simple inductions. We may select our facts in physical science and arrange them so as to make the conclusions to be drawn from them as simple as we choose. Nature performs many physical experiments in a large way; these as encountered in physical geography, may be too large for the youthful mind to encompass. We may perform in the physical laboratory experiments which represent the large phenomenon piecemeal, and thus build up the conception of the whole, and at the same time develop the constructive imagination, which is needed to grasp the process of nature. Often we may devise for the laboratory a miniature representation of the larger phenomenon of nature which shall be quite a perfect analogy. This not only shows the possibilities of laboratory work in chemistry and physics, but I believe it indicates in a general way a very important aim to be kept in view; viz, to select as far as possible such work as will prepare the way for the biology and geography to follow. I should teach chemistry and physics in the high school, not solely, perhaps not chiefly, for their own sake, but rather for the sake of furnishing a foundation for other work. Prof. Tarr says: "Geography is a complex of all the sciences." So also is physiology, we may say. Now physiology runs through all biology. Whatever may be said of the study of plants and animals in the elementary school, in the high school I believe it should be chiefly the study of animal and plant physiology; and physiology deals to a very considerable extent with the chemistry and physics of living things. James E. Peabody, in the preface of his excellent laboratory manual of physiology, says: "Since physiology unfortunately precedes physics and chemistry in the ordinary high school courses of study, it is necessary to give the pupils some idea of the fundamental principles of these subjects." Foster & Shore, in the preface of their little book called *Physiology for beginners,* say: "A sound knowledge of physiology can not be gained without some acquaintance with chemistry and physics, and at least a rudimentary knowledge of these ought to be obtained before the study of physiology is even attempted." The report of the committee of ten states it in these words: "The study of physiology is in a great measure the study of the mechanics, the physics and the chemistry of the living body; before it can be pursued profitably the student should have, at least, a fair elementary knowledge of these sciences as fundamental. It is not possible to teach it as science to pupils devoid of such knowledge."

Dr Franklin W. Barrows of Buffalo, states the case for zoology as follows:

> The time for the course in zoology should be, if possible, not earlier than the third year in the high school, and the pupil should have completed his laboratory course in physics and chemistry. It seems to me that any teacher who has had practical experience with laboratory work in other sciences as well as in biology, would prefer that his students should lay the foundation of their science work in the study of physics and chemistry rather than in biology. Many teachers of zoology and botany are attempting less with their classes than they would like to attempt, because they are constantly reminded of the limitations of their pupils — the untrained eye, the unskilled hand, and that disregard for the exact truth which incapacitates so many young people for any original or accurate accomplishment in science. Then again the problems of biology, involving the consideration of animal function and structure, require a greater degree of intellectual maturity than those of physics and chemistry. For this reason there is an immense advantage in postponing this work to the third or fourth year instead of plunging into it at the beginning of the course.

So much for logical sequence. Now, is there anything in the nature of the pupil which demands a different order of subjects from this? If so, I yield to that demand as imperative; but I have not been able, by 19 years of experience in teaching the various sciences to high school classes, and by careful consideration of that which has been written and spoken on the matter, to discover any reason why this is not also the order of subjects demanded by the best interests of the child. It has been said that green things and living things appeal most to the interests of the pupils, and this is given as a reason for putting their study first in the course. I have been at a good deal of pains to examine into this matter, and I do not find it so. On the other hand, my evidence, gained from the children themselves, is overwhelmingly in favor of the statement that all pupils are very much more curious about what they may see in a chemical or physical laboratory than in all outdoors. But there is a wide difference between being interested in things and being interested in the formal study of things. On this score, however, if it is necessary or desirable to keep pupils at a white heat of interest, the teacher of chemistry or physics has the advantage. This bidding for the interest of the pupil is, nevertheless, in my judgment, a very undesirable proceeding. I assume that any capable teacher can do his work as it should be done without the necessity of competing with some one else for the interest of the pupils. If pupils *are* more interested in one subject than another, that ought not to be the only argument, nor the principal argument, for putting that subject in a certain place in the curriculum. A wholesome interest in a subject on the part of the pupil I regard as essential to his success, but a good teacher of any one of the sciences need have no lack of interest. After all, the argument of interest is all in favor of the logical sequence of the subjects. One great aim of science teaching is to accustom the mind to logical arrangement; to make one thought grow out of another; so to arrange things that one phenomenon shall appear in its relation to another, that one fact shall throw light on another; to organize our everyday observations. The logical sequence not only of topics but of subjects is just what is needed to gain and hold the interest of the pupils.

It has been said that it is not the aim of teachers of botany and zoology in the first year high school class to teach science, but rather to teach observation. This is called a faculty, and it is alleged that it will be useful to the student when he takes up science later in his course, possibly in college. This is compared to whetting one's tools for future service. One might as well say that it is not the aim of history teachers to teach history in the early part of the high school course, but rather to teach memory. Many books of object lessons have been published for the purpose of teaching observation to children as a mechanical process, so that they may have the faculty all ready to use when they get older.

This is stupid and stultifying business. A person thinking much on some question, the answer to which he expects to find in nature, is liable to see things which cast light on his problem, while at the same time he may be very unobserving of those things which do not help toward the answer of his question. This is scientific observation. Children are natural observers. They need only to be taught to select for a definite purpose, and to connect one observed fact with another. This, I imagine, is what Prof. Huxley meant when he said, "Science is merely organized common sense." The number of observations which a person may make in a given time is often inversely proportional to the amount of thinking he does. A child and his father go to walk. By the roadside they both notice some object as they pass along. The father, having had a wider experience, finds something in this object which starts a train of thought. The child, not being so occupied, sees numerous other objects which the father fails altogether to notice or which, if he does notice, flit across his mind without making any impression. But presently an object attracts his attention, and, because it is related to the first, it attracts his attention more than it does that of the child. The number of objects seen by the child during that walk may be to the number seen by the father as 10 to three, but the father has seen related things; he has seen to some purpose; he, of the two, is the scientific observer. Yet, if some one asks whether they passed a certain gate, the boy will be very likely to be the one who can answer. Now, no teaching can enable the boy to see more things, but training may enable him to think more about what he sees. Some one has said that a good memory requires a judicious forgetfulness: so scientific observation requires that the mind shall not be distracted by observing a multitude of unrelated things. Hence the teaching of scientific observation brings us back to the logical sequence of subjects. This logical sequence in a high school course I hold to be: first year, chemistry; second year, physics; third year, biology; fourth year, geography.

High school pupils may properly be expected to work, in school and out, five and a half hours a day. Or, taking the school period of 40 minutes as the unit, eight periods a day. Five of these periods may be taken in school and three may be devoted to study at home.

The pupils in the Horace Mann high school, which is controlled by Teachers college, attend school 32 weeks in the year, and the course is four years in length. Eight periods a day, five days in the week, 32 weeks in the year, for four years, make a total of 5120 periods of work in the whole course. I believe one fifth (one quarter is recommended by the committee of ten) of this time, or 1024 periods, should be devoted to science; and I recommend the following scheme:

| | Periods a week in school | Periods a week out of school | Whole number periods a week | For the yr of 32 weeks |
|---|---|---|---|---|
| 1st yr chemistry ....... | 4 | 2 | 6 | 192 |
| 2d yr physics. ......... | 7 | 3 | 10 | 320 |
| 3d yr biology. ......... | 7 | 3 | 10 | 320 |
| 4th yr geography. ...... | 4 | 2 | 6 | 192 |
| | | | | 1024 |

It being desirable to consider whether the above arrangement would leave the course well balanced, I append herewith a schedule showing a fair allotment of time to other subjects.

| | "Week hours" Pre-pared[a] | "Week hours" Unprepared | Total In school and out | Total periods In school and out for 4 years of 32 weeks each | |
|---|---|---|---|---|---|
| English and history.... | 20.... | 0 | = 40.... | 1280 | = 25% |
| Science. ............ | 10.... | 12 | = 32.... | 1024 | = 20% |
| Mathematics. ....... | 11.... | 0 | = 22.... | 704 | = 13.75% |
| Manual train. and draw. | 0.... | 20 | = 20.... | 640 | = 12.50% |
| Modern languages .... | 13.... | 0 | = 26.... | 832 | = 16.25% |
| Latin. ............. | 10.... | 0 | = 20.... | 640 | = 12.50% |
| | | | | 5120 | |

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[a] Requires an equal number of periods out of school.

**J. E. Peabody** — As Prof. Woodhull has quoted me in his paper, may I be allowed a moment, Mr President, in which to make clear my position? It is true that the preface of the laboratory manual contains the statement, "Since physiology unfortunately precedes physics and chemistry in the ordinary high school courses of study, it is necessary to give the pupils some idea of the fundamental principles of these subjects." If I were to rewrite that preface at the present time, however, I would strike out the word "unfortunately." That the pupil should be made acquainted with some of the simpler principles of chemistry and physics is essential for any comprehension of biologic facts; but these necessary principles can be presented, I have found, with sufficient thoroughness in the first eight to 10 recitation periods devoted to the study of biology.

**Prof. W. F. Langworthy** — To those who are interested in the teaching of science, this is a time of great encouragement. Never before did our work occupy so prominent a position in the popular mind. Never before did it have so large a place in courses of study. Never before was so much attention given to careful methods of presentation. In the light of these facts, it behooves the teachers in secondary schools to be diligent in seeking the best ways. The sequence of the sciences in the secondary school curriculum is a question well worth our consideration.

Two conditions, which now exist, make changes in methods of science teaching easier than they were a few years ago. First, the more general introduction of nature study in the grammar schools lays a foundation for future progress. I welcome this as a great help to science work in secondary schools. Even if the attention of the boys and girls can be called to only a few simple facts, their aroused interest and correct observation will be of incalculable advantage. I believe on my own observation that they will actually learn many things. Our deepest gratitude is due to the individuals and institutions that are leading in presenting this matter in proper form to the grade teachers of the state.

In the next place, the colleges welcome any changes in right directions. They are now giving science a place in entrance requirements for which it long sought. They are ready to accept science work well done as a full equivalent for work of like quality in other subjects. You will agree with me in putting this stronger and saying that they are making a real demand for such work. If there is an interrelation in science subjects which makes one order of presentation the natural one, the attainment of this order will help very much in meeting the requirements of the higher institutions. But far more important than this is the advantage to the boys and girls of a correct method. The rising generation is more important than the schoolmaster or his theories.

The order of sequence in science studies is not a matter easily decided. We can not at once step to a conclusion with mathematical certainty of reaching the proper arrangement. Possibly no two of us would agree in all details as to the proper order of science teaching. Still the free and full discussion of the subject by those engaged with different grades and in different relations can not but bring us in time to right conclusions.

I take it for granted that, if we can reach the logical order of development in science work, such an order will on the whole be best for the student, and that such limitations as state regulations or college requirements, which might interfere with the new plan, will soon give way. Difficulties as to proper books will be readily overcome, for publishing houses want popular books and progressive teachers are glad to produce them.

Of the three great groups of science subjects, logically physical science should stand first. Many of its facts and principles possess a simplicity and exactness not found in biologic or earth science. 'Its reasoning approaches the definiteness of mathematics. Apparatus for illustration and experiment, in a course suitable for preparatory schools, is easy of manipulation and the certainty of the results gives satisfaction to the youthful mind. That most matter presented in nature study will come from the biologic group is an additional reason why the physical sciences should have the more prominent place.

Of this group of sciences physics deserves the first place. It appeals more strongly to the average young person, though I own this is not a very important consideration, since no branch of science lacks interest to the ordinary mind. In its relations to the other branches physics appears to be fundamental. Chemistry advances the appreciation of physical truths in but few direct ways, while physics illumines a multitude of chemical facts.

It seems certain that high school textbooks in chemistry are less difficult than those in physics. Considerable knowledge of mathematics, which can not be presented till later in the high school course, is needed for the successful use of the books in physics. It also looks as if the colleges asked for a treatment requiring this knowledge. The question still remains whether the colleges would not find results as satisfactory if a course was given requiring no knowledge of geometry. If the colleges were satisfied with this, the difficulty with textbooks would soon vanish because of the making of new ones.

I admit that chemical apparatus is less expensive and more simple of manipulation than physical apparatus. Still the difficulty would partly be done away with if the high school and college work were more perfectly differentiated, if the bounds of high school work were clearly defined and carefully adhered to.

I also regard physics as the more important branch of science for the average person. It touches the everyday life of men and women alike. Irrespective of station or environment, its facts are ever before us. If it stood first, more would gain a knowledge of its principles, for it is well known that a large majority of those who come to the high school never complete its work. For these reasons I would place physics first and require it in all courses. This requirement can be more easily satisfied at the beginning than later, when many of the studies pursued by scientific and classical students must be different. I do not however regard it as nearly so important that physics come before chemistry as that physical science precede biologic and earth science.

After the course in physics and chemistry should come the biologic sciences. The cultivation of the power of generalization and the skill in manipulation of apparatus already gained are a great advantage. To pass from the study of dead, inorganic matter to matter organized in living forms will stimulate interest. Besides, this seems to be the natural way of approach.

Of this group biology should be taken first, since it holds the key which unlocks the mysteries of the other branches. It seems almost indispensable as a preparation for work in physiology, one of the subjects to which is rightly given an important place in our educational system. For practical reasons this subject should be made prominent. I believe that valuable training in science can also be gained from it if rightly pursued. Biology forms a natural introduction, giving one a knowledge of the characteristics and functions of the cell, the unit of the structure of the living body. The relation of physiology to physical science has been expressed by the statement that it is but a practical application or illustration of the facts of physics and chemistry. Biology is equally important in preparation for botany and zoology, the first of which, at least, should have a place in the high school curriculum.

The last year of the course should be devoted to work in earth science in which physical geography, or physiography, should have the most attention. To study the earth "as the abode of man" and gain from it all that is possible needs a careful and broad preparation. This our student now has and the subject should be so presented as to call into use a large part of his previous acquirements in history and science. I would try to make him see the origin as well as the present conditions of the land forms and their influence in shaping history and human life. For example, he should understand what geographic conditions have led the Englishman to enter the territories of the Boer republics in South Africa and why it is that a handful of farmers are able to hold at bay the armies of one of the strongest nations. With geography for the culmination, a well rounded knowledge of elementary science is provided, and our pupil is ready to go farther in any branch of science in college.

### Thursday afternoon

### SECTION MEETINGS

## Section A. BIOLOGY

### REPORT OF THE SUBCOMMITTEE OF THE COMMITTEE OF NINE

## The secondary school course in zoology

BY PROF. C. W. DODGE, UNIVERSITY OF ROCHESTER

### MINORITY REPORT

BY J. E. PEABODY, BOYS AND GIRLS HIGH SCHOOL, NEW YORK

*Questions proposed for discussion.* During which year of the high school course shall zoology be taught? Shall the pupil dissect specimens? Shall scientific terms be used? How deeply into classification ought the pupil to go? Shall zoology be preceded by physics and chemistry?

[The reports appear as a part of the report of the committee of nine, on p. 743.]

**Prof. H. R. Linville** — Considered wholly from the standpoint of the zoologist, the report of the committee appears almost perfect in its completeness, but no attention is given to the claims of other sciences, and no opinion expressed as to the ideal relation of zoology to chemistry and physics. The enormous amount of work recommended by the committee for the high school course is evidence of its opinion that the student should learn enough zoology in one year to enable him to *teach* the subject later. By adopting such a plan we should not only be doing the work of the high school, but attempting the duty of the college and the training school. Moreover, it is not possible to become acquainted with any science at one undertaking; and the purpose of high school courses in science should be simply to give the student a broad, general view of the subject, introducing him to principles which may be more thoroughly understood on continuing his work in college.

In addition to recommending the study of the external structure, the activities and the classification of all the principal groups of animals, the committee insists on the dissection of a representative of each of the large groups, which probably means that at least eight or 10 animals should be studied in this way. Such a feat is absolutely impossible if the work is done well, and if the dissection be not complete the time is wasted. I agree with the recommendations of the committee in the main except in the important matter of dissection. Dissection is of the nature of special work. It should never be undertaken till the student has a fairly complete knowledge of living things in the condition in which they are most likely to come into his experience. Dissection should follow then in another course, as detailed knowledge follows the introduction to any subject.

If it were possible to carry out the committee's course in zoology, it could not be even attempted before the third year in the high school, when the student's capacity for work is fairly developed. If the subject of zoology is to come in the third year, we may assume that physics and possibly chemistry as well will precede it. I can see but one reason why zoology should be placed as far along as the third year, that is the very poor, uncertain one, that more work will be done by the student. There are, however, two good reasons why zoology (or biology) should precede chemistry and physics. First, experience has shown that the native curiosity of the child grows less extensive and more intensive with age. A peculiar circumstance attendant on this change is the beginning of an indifference, and in many instances an inability to appreciate natural objects. A boy of 14 will enter on the study of biology with an enthusiasm which a boy of 18 seldom displays. The second reason implies some consideration of the philosophic relation between the subject-matter of biology and the subject-matter of physics and chemistry. The principal argument for placing physics and chemistry before biology in a course of study seems to be this: physics and chemistry deal with the elementary processes of nature and therefore the study of these processes logically precedes the investigation of the complicated phenomena of animal and vegetable life. Those who argue from this point, are proceeding in ignorance of the way a child's mind, or any untrained mind, naturally works. The philosopher, on becoming acquainted with primary phenomena, continues to the explanation of their appearance in complex nature. To pretend that a child may do such a thing is ridiculous. The child is interested in the bird that flies before it, or in the squirrel that comes for the nut. The interest of the child in the squirrel is enthusiastic, and, as a result of this enthusiasm, the child gains definite knowledge of the squirrel's external appearance and its habits. Knowledge of living things might be extended indefinitely under the natural stimulus of the child's desire to know what is about it. It would be strange indeed if the child or immature youth should think to analyze the complicated phenomena which he had seen.

Both reasons that I have given why biology should precede physics and chemistry are based on the principle of interest. Since the interest of the young mind is a natural one, it seems most expedient to seize on the opportunity offered and develop from the enthusiastic general interest a scientific, discriminating method of regarding the processes of nature.

**Prof. C. W. Dodge** — I am strongly in favor of having zoology and botany combined in a course in biology; and I think that the committee would have been very glad to prepare a report on teaching biology. But we were asked to prepare one on zoology, and it seemed best to confine our report to the subject assigned to us. So we have said nothing whatever about combining the two lines of study.

**Prof. C. W. Hargitt** — I want to refer to one thing which has been brought up several times during the day, and has been discussed by the committees, that is the difficulty in securing an early place for physics and chemistry in the high school, and the fact that, in view of this difficulty, some of these committees, that of the National educational association for instance, have recommended that these studies be put in a later year, the second, third or fourth year of the high school. We must not lose sight of the reason given for that. It is not that the zoologic or botanical work is better adapted to the earlier years of the course, but the difficulty that is involved in getting mathematics, physics, etc. in earlier, by reason of the conditions underlying them.

It seems to us utterly impracticable at the present stage of organization of science teaching in the state and in view of the conditions in the schools to recommend two courses in zoology or two in botany or a course in general zoology and a subsequent elective course in botany. The most we can hope to do is to secure a year's work in biologic science. We should like to have a year course in botany, as the committee last year proposed, and the idea of this report likewise is to furnish sufficient material for a year's work if practicable. If the conditions in a school are better adapted to a year course in botany than zoology, I think the committee would say that that is the best thing to have; and conversely, if the school is better prepared to give a year course in zoology than botany, the committee would insist that *that* is the proper thing to do.

Another thing that we should not lose sight of is this; that there must be more or less flexibility in any course for these schools. This is necessitated by the conditions of the schools and the teachers. There are not facilities in all the schools for a year's work in all of these biologic sciences; and, if there were facilities, conditions otherwise might not make it practicable. We must recognize the fact, and the committee is prepared to make that concession. This course is to be flexible. Such and such studies need not be studied by such and such methods. It is not absolutely necessary that a dissection of a typical member of each branch of the animal kingdom be made, but of as many as is practicable.

We must not lose sight of this farther fact. A good deal of this elementary nature work is to enter into the school work of the future. This elementary training, observation of outdoor life and in the museum, which is to take hold of the innate curiosity and the observational capacity of the child, is to be put into the grammar grades. After this movement has become actual, and we have realized in the grammar grades something of the results of nature study, we shall be prepared in the high school to take up and successfully carry forward a higher type of zoologic or botanical teaching than we are prepared to do at the present time. The recommendation of these other committees, the National educational association and others, to put the biology course earlier, is a concession to conditions which may change after a while. Then this elementary work, satisfying the curiosity and offering opportunity for observation, is likely to be met more or less perfectly very early in the nature study, as it is being rapidly introduced through our whole state.

Another thing must not be overlooked. We need to do really first-rate work in the high school if we are to have it accepted for entrance to college. This committee has not lost sight of the fact that the work done by the high school in zoology and botany will come up as entrance college work and claim recognition. If this work in zoology and botany is accepted for admission to college, we want to have something that is really of training value in a scientific way, that trains as truly as any other work accepted for entrance. If I am to accept this work for entrance to college, I want it of such a character that I can build on it. This training in botany and zoology in the high school must give some kind of ability for advanced study in college, or what is the use of having had it? It must be genuine, must have been done so satisfactorily that in the college we can proceed to build on it, in the same sense as is done in language and mathematics.

**Prin. E. J. Manly** — There seems to be a great desire on the part of the principals here, as there was at the principals meeting, to do this laboratory work and have the work of the sciences examined under an inspector rather than by an examination. I think that the great difficulty is that the common schools have not the facilities to do this work. They would like to. Another reason is that many of the principals don't know how. They haven't anything definite to turn to. Do you know of any outline that would help us?

**Prof. C. W. Dodge** — The committee has prepared an outline, which will be printed in the report.

**Prof. J. H. Stoller** — I wish to say a word by way of approval of the report of the committee in respect to making the basis of the high school course in zoology the study of a series of types including dissection. Perhaps some of us who attended the meeting last year or have read the printed report of the papers read at that meeting, have been somewhat unsettled in mind as to whether zoology should be taught with emphasis placed on the morphologic side of the science or whether this was all wrong and our work should relate wholly to the study of the living animal. Speaking for myself, I am pleased that the report goes back, or at least from this point of view, goes back to the old method. It seems to me that what one may perhaps speak of as the backbone of a course in zoology should consist of the study of a series of types. It affords the best training in observation and in the use of the logical faculties. It may be very well that the study of the living animal shall be carried on along with the study of the type, from the point of view of structure. As much of this should be done as possible. But in many schools it will be found difficult to do very much; and that brings forward a strong reason in favor of the study of types, viz., that it is the most available course, by reason of the ready accessibility of the material, and also because it is a course that any teacher can teach.

I have been very much interested in the question of sequence of studies as between the biologic group and the physical group. From the point of view of the college teacher, I am convinced that chemistry and physics should precede the biologic studies. I feel that perhaps in the high school the study of organisms may be taken up before the study of chemistry and physics. But it appears to me that if the course is to be in the first year, it must certainly be comparatively superficial in so far as it relates to the study of function. I think that possibly there is a little inconsistency in the view that the study of organisms should be from the point of view of cell life and should at the same time come the first year. How is a pupil to understand the life process unless he has had a preparation in physics and chemistry? He can learn what the products of the activity of the cell are; he can learn the results of the processes going on in the protoplasm, but he will be quite in the dark in regard to the nature of these processes unless he has had a preparation in the study of the molecular structure of matter, chemical reactions, etc. Of course I keep in mind the fact that no final conclusions have been reached in regard to the nature of protoplasmic processes, yet as much as is known is expressed in terms of chemistry and physics. It seems to me therefore that, if the study of biology is to come in the first year, it can not be carried on strictly from the point of view of function, and I fear that, if this association were to recommend placing biologic studies in the first year, one result might be that in botany we should go back to the old courses, where the work consisted chiefly of the collection of specimens and the determination of species.

**Inspector A. G. Clement** — I do not intend to take up much time but I wish to express my great interest in the report, and to say that we all ought to be grateful to the members of the committee for the work they have done. They have certainly made a most excellent report, and one of its good features is, that it is flexible, and schools can probably adopt its principal suggestions without disturbing the whole course of study.

One idea that comes to my mind is that we are liable to forget that the student in the high school has something to do beside the study of science. A pupil is expected during a course to get not only some knowledge of science, but also of language, history and mathematics and certain other studies which are introduced into high schools, like manual training, sewing and similar work. Now, if we expect a student to take up physics and chemistry and afterward botany and zoology, we are looking for something that will not be done, and, I believe, ought not to be done. It may be well to pursue science exhaustively after a pupil has had a high school course in which a variety of interests has been presented to him. But in a high school he should not devote all his time to history, science or language. I think it is generally considered that the student whose mind develops properly and harmoniously must be drilled in at least five different lines. He certainly should pursue studies which represent inorganic matter; he ought to pursue studies which represent organic matter; he should receive some drill in language, and that means, if he is preparing for college, not one language only but two or three foreign languages; he should receive some training in studies which develop the will, such as history and political economy; he should also have training designed to develop his esthetic nature, through the study of literature, drawing, etc. Here are at least five departments in which his secondary course should provide training. If you put too much science in the course, some other part will fail to receive proper attention — some interests latent in the cells of his brain will not be awakened, and the result will be that the mind of the student will not be developed harmoniously.

We have had various reports, a special report on modern languages, one on mathematics, another on history; but it seems to me that each study is ambitious for more than its share in the high school course. It is time for us to consider the child and remember it is the child we want to educate. It is not scientists we desire to develop in the high school, nor linguists nor historians, but men and women. This should be considered in making up the course of study in science. How much then can we fairly require? I think that, if we are to consider the requirements of history and language and mathematics, we can not consistently require more than one year for biologic science and one year for physical science, and I am not sure that we can get all that. But even this gives students at least a start, helps them to form an interest in various directions, which they will develop in after years. Besides, such a course will contribute to a well balanced mind, will produce a good citizen, and that is what we specially desire in this country. We need a development of society in general rather than the building up of individuals in one special direction.

If we put in physics the first year, chemistry the second year, then bring in botany and then next year zoology, we are asking for something which we can not get. I am in favor, from observation of the condition of the schools in the state, and also from the pedagogic point of view, of taking up biologic science in the first and second years, specially if a few experiments to illustrate some of the fundamental principles in physics and chemistry are explained. We must remember that each of these studies has an educational value. It is this that we want to get out of these subjects in the high school rather than the knowledge alone.

I think that Dr Dodge hit the nail on the head when he said that zoology and botany should be studied from the point of view of the evolutionist. If they are properly conducted under a good teacher, the pupil will get that point of view; he will certainly learn a few practical things. He will learn that things grow; that they do not come forth in the world fully endowed.

The development of biologic science in the schools must be an evolution in itself; it must come by gradual processes. I think that in course of time, if we keep at it, we shall get a very good biologic course in the high schools.

We must also remember that the object in the study of any of the sciences is the formation of the mind, the making of the man. If a pupil masters the idea involved in the study of zoology or botany, the evolution of matter, he will learn that things progress from simple to complex, that things develop, things grow. If he forms his mind in this way, when he gets out into the world, he will not expect great results to come immediately, but rather gradually. He will not expect to take the whole world at once and grasp all its prizes. He will have learned in school that things grow, that one thing follows another, that there is a relation between cause and effect; and this is a great lesson for a young man to learn.

More than all that, a pupil who has had a good course in biologic science in the first year can acquire history much more easily. The method of evolution is not merely in zoology and botany but also in history and civics and in all phenomena of life. If he leaves these studies till later, he will lose the benefit of this method.

The introduction of dissection into the schools throughout the state will be a difficult matter, specially outside of the cities. At the present time there are not more than 10 schools outside New York city that are doing either botany or zoology work on the lines laid down in the syllabuses, and you will be surprised to find how great opposition there is in the smaller towns to dissection, specially of a cat or a rabbit. There is no great fuss about pulling bugs apart, but, if you touch a cat, you create a commotion at once in a community. The incident is immediately reported in the papers, sent down to New York city, and published in some of the sensational papers of the metropolis.

Another point about this special topic business. It has occurred to us that perhaps, by mentioning one or two animals which would be suggested for dissection, we might gradually work dissection into the schools. I believe its introduction can be brought about in a gradual way without any commotion, whereas, if we insist that every specimen shall be dissected, we shall have a reaction and three fourths of the schools will express their opposition and object to the asking of questions along these lines. Either that or else they will take the various manuals on zoology and study up and commit to memory points about dissection, answering the questions in that way.

In the course of three or four years the study of these various reports will help to get the studies properly taught in the schools. We must not expect too much at once and must be satisfied if there is good teaching after three or four years. The teachers must also learn that it is not necessary to have a large room set apart and fully equipped in order to do laboratory work. This is brought out in the report, and will no doubt have its effect when it is printed. I think a sufficient number of these reports should be printed to supply all the teachers who want them.

**Prof. S. H. Gage** — My work has always been in connection with the university; so I am familiar with no high school work except at second hand. In hearing the report and the discussions that followed, I was trying to put myself in the place of the high school teacher and see what under the sun I would do if this thing confronted me, and I must say I am puzzled. I have five hours throughout the year to teach histology and embryology. We have four assistants and a magnificent room and yet we can not half do the work. But the high school teacher, with all the other subjects he must deal with and the room that he has to work in — it has really puzzled me to say what he can do at the present time, and I have put down as one of the points to consider, the question of time.

I should say, Mr Chairman, that to carry out consistently the work that you have given there, I should want about three years. It would then be a course worth while, but it could not be done well in one year.

A high school ought to take into consideration its conditions, its pupils and their surroundings and do the best it can for those particular individuals; and, that being so, there can not be one universal guide for all the high schools taken together. We are often charged at the present day, scientific men particularly are charged, with putting everything into the line of specialties. They say this is an age of specialization. Now I take it, from the meetings I have attended, that the trouble is, this is not an age of specialization. There is where the whole difficulty lies. These subjects are not the only ones we are going to study. Look at the Harvard curriculum of a hundred years ago and that of today, and if any person will tell me that today is a day of specialization and that was a time of broad, general culture, then he has a queer notion of what the two things are. At that time one could go to college and study Greek, Latin and mathematics with a sprinkling of natural and moral philosophy, rhetoric and history and when 17 or even younger receive the degree of B. A., and thus become an educated man. That was indeed the golden age of specialization!

In this university [Syracuse] see the diversity of the subjects. I think that anyone, after looking at the catalogue of this and the other colleges, must feel that the age of specialization has passed and the age of generalization has arrived.

Another point. As the university has found it impossible to give every student who takes its degree the same work and all the work given, so will it be impossible for the high school to go on in a settled curriculum. The high school will have to offer a variety of courses. The student who desires to study particularly history and the humanities will have to take one direction, the student who is interested in science will have to take another and so on. We may deplore that day but I feel certain that it is coming.

The medical college, like the academic college, say a hundred or even fifty years ago, had a very simple curriculum. I call your attention to the first Huxley address by Dr Michael Foster. ["First Huxley lecture — Recent advances in science and their bearing on medicine and surgery," *Nature*. vol. 54, 1896. *Annual report of the Smithsonian institution* for 1896, p. 339] He discussed medical education at the time when Huxley was a student. As he describes medical education at that time, it was very simple, but, if we take the medical education of today, we find it as complex compared with that as is the college of today compared with that of a hundred years ago. What we are trying to do at the present time is to let every student who wishes to study medicine go through the whole of it. It is as if every student who came to Syracuse university had to take the whole curriculum. It is not a success and the most eminent medical men are saying that the medical curriculum can not be a unit; there must be specialization.

I believe we have a perfectly tremendous problem before us, and that is one of the reasons why this association exists. I should like to say something, though out of the line of the general argument, on the order of subjects. In my experience as a teacher I have found that a pupil, to get the best grasp of any subject, ought to have had all the other subjects first. As Prin. Stowell said, we all want the seniors. It does not make any difference what a man's training has been; if he has had training, he can take up a new subject and do it better than an untrained man. But I do not believe we ought to worry much about the sequence of studies. If I had a dozen boys, I would not care much where they began, if they only commenced somewhere in earnest. What they learn in biology will help them some time in something else, and what they learn in physics and chemistry will help, and so on.

I wish to express my gratification at the report. That, or something like it, is what we ought to have. But the question is, what can we actually do? That is what ought to be done, but can it be done with the other things that have to be done also? Let's try to do a little this year, a little more next year, and finally, when we divide up into optional courses, we shall have time to do the whole of it and do it well.

**Prof. H. A. Surface** — I believe that each school should be complete in itself, the grammar school giving training for the pupil, not for the high school, the college, or the university. Whatever is in a pupil should be developed in the grammar school and at the same time become the basis of the high school work. The high school teacher should know what the pupil has had in the grades in order to base his work on it; the high school work being complete in itself, designed for the pupil not for the teacher of the higher institution. Then we are not taking for granted that the pupil will go on through the university. We ought however to take for granted that he will finish whatever he undertakes either in the grammar grade, high school or college. Each should be complete in itself, but each of the higher based on the lower.

We are arriving at something like a solution of one of the problems before us. I wish to lay stress on the first and second points in the very excellent report before us. I have found a feeling of repulsion in many of the pupils in the first dissection. We should start with animals commonly used for food, the chicken or pigeon, and then a rabbit, next perhaps a frog and next a cat. By the time this is reached the parents will have heard the children speak about it till they think perhaps there is something to learn. I have been able to do that and to introduce dissection into the very lowest grade with no objections. Pupils are prepared after about five animals for almost anything that comes. I would suggest that the animals be killed, not in the presence of the pupils, but in some humane way outside the class. All blood should be wiped away. Drawings are important in dissection before presenting animals to classes. I should like to emphasize that point. My pupils make drawings one day and have an opportunity to correct them next day. I make an outline one day, the next day go over the subject again, leading them to discover the principal mistakes that have been made. I would also make emphatic one point concerning museum preparation. Each one should be required to show some good thing and show it well. I have found by experience that skins of birds properly prepared are much better than mounted birds for study and class use. They can be stored in small space, whereas it takes a large case to show even a few mounted specimens. The pupils can handle these skins and can not handle mounted specimens. Of course the teacher will have to learn how to prepare the skins and teach one or two pupils to do it.

Too much work of this kind, killing birds, robbing birds' nests, etc. is a great evil; it affects the pupil seriously. I should advocate the collection of specimens of types of families, at least one representative of each zoologic family, to show structural characters. I should have no shotgun on class excursions. I would at this time of year advocate the collecting of birds nests, as that does not harm the birds.

As for an aquarium, to simply put it in the room and let it stand there, stocked with fishes, insects and similar material like a small pond, would be useless. Simply looking at the material will not answer the purpose. If looking at material were to make naturalists, the Indians ought to be the greatest naturalists in the world. They were great naturalists in one way and that was in knowing nature for their economic purposes. My method is to stock the aquarium, and to post at the side a sheet of printed questions, directing the students' attention to specific points. For example: how fins are used when a fish swims backward, forward, and turns around. The pupil writes down the answer to each question in his notebook. I go over the work, mark the answers that are wrong, have pupils look again to discover what is true, and call attention to answers specially good.

I would make a plea for a greater study of life history than has been recommended in the report. This feature of zoology has been neglected in many schools till comparatively recently.

As regards the order of the sciences I would suggest this. Oecology is becoming recognized as of great importance. The study of conditions that exist in various places and the causes of the difference makes it even broader than biology. Later let it pass into biology, which is a more limited or more technical feature of science. For the second year teach the chemical or physical sciences, not changing to botany or zoology. The pupil would thus be gradually led into the specialization that comes in the higher education. There is no doubt that our higher educational institutions are institutions of specialization. In the freshman and sophomore years there is not so much specialization, but, as a pupil goes higher, he necessarily becomes more and more of a specialist. In the third year he can and does take work of a more specialized nature than in the first year.

I would enter a plea for the better training of teachers. To do this work properly, the teacher must be trained in the subject and the methods. A teacher who is able to lay down a plan or course of study and follow it will not need to follow any other line. If I were teaching in New York city, I should pursue a different method or perhaps different topics from what I should follow at Rochester, Syracuse or Buffalo. To be original and effective means a training which only increased salaries can make possible or justify.

**Prof. C. W. Dodge** — The matter of life history has received a good deal of attention in this syllabus, as will appear in the reading of the report.

**Prof. A. D. Morrill** — I have been much interested in listening to the discussion. Two points are being considered and have been discussed very fully. I don't know that I can add to them. One is the great importance of biology and zoology in the first year by way of training. I believe that those who know anything about zoology from a practical standpoint will most heartily commend in every detail the syllabus that has been presented. In order to carry this out, it will be necessary probably to make that study an elective in the third or fourth year.

The last point, in regard to the necessity of training teachers, is highly important. We are looking forward to the distribution of the syllabus and the discussions for the effect on the teachers. We hope that each year there will be a few teachers who will try to do something. If they can gain a little each year, they will not rest quiet till they have the whole.

**Prof. P. A. Fish** — This is my initial attendance at this association and I came rather to receive than to give. I have endeavored to absorb as fully as possible the discussion that has taken place both this forenoon and this afternoon. The impression I have received is that there has been perhaps a tendency on the part of some to isolate the different sciences, to pen up in distinct fields the science of physics, the science of chemistry and the science of zoology. It seems to me that all these are dependent, in a way, on one another and that biology is dependent on the others to a greater extent than they are on it. If we might, for example, refer to the science of physiology, in which I am more directly interested, we have here the science which is perhaps the most dependent of all. Physiology is embedded in anatomy and histology. It is dependent on chemistry, or at least chemistry is the underlying basis of digestion. It is also dependent on physics. Take the changes that occur in the cells during absorption, or during the discharge of the glands; certain physical as well as chemical processes are involved. If we take away chemistry, physics, anatomy, what is left of physiology?

So it is not a bad idea, I think, to adopt the suggestion of some, that biologic sciences be given in the first year, and teach along with and coordinate with them enough physics and enough chemistry to throw light on certain points. When we are discussing a special subject in physiology which involves a little physics, or a little chemistry, introduce it at the time when it is needed; then it will bear full fruit. I believe in the commingling and the community of these different sciences rather than in their isolation.

**Prof. C. W. Hargitt** — I would not be understood to say that the course proposed here was proposed specifically in reference to college work. What I intended to say was this; that it is the design of the committee to prepare a flexible course, and that we do not want to lose sight of this fact, that the work of zoology in the schools should have sufficient flexibility to adapt it to meet the possible requirements of a college student who is prepared to offer that as one of the college entrance studies. My whole plea has been that it shall be a flexible course. It should be understood, if this report is adopted, that it is simply a *suggestive* report and that it is left for the live teacher to make it most fully serviceable.

**Dr H. L. Taylor** — I want to ask two questions. First, how do the requirements of elementary biology in the first professional examination of the medical examining boards of Great Britain compare with the treatment of biologic subjects in New York state?

Second, can combination and condensation place biologic subjects of our high schools in the fourth year to meet the requirements of the examining boards of Great Britain?

**Prof. C. W. Dodge** — I do not think I can answer the first question. As to the second, I judge that the method of instruction pursued in Great Britain is the method which we are trying to discard, the method of verification. A student simply verifies what his laboratory book or textbooks tells him. That has led to a great deal of cramming for examinations, with practically no attention to the acquirement of actual knowledge by the student himself.

**Prof. H. A. Surface** — How would you recommend treating dissection? One specimen for the whole class? Or how is it done to the best advantage?

**Prof. C. W. Dodge** — I have always found that the most desirable material to use is that which has been preserved — alcoholic material in the past and formalin material in recent years. One reason for this is that there is no tendency of the blood to run; besides, the preservative fluids do much to harden and separate the various parts from one another. The parts stand out in almost diagrammatic clearness. The color is not always well kept, but I think there is far less objection to dissecting a cat which has been kept in preservative fluid for a time than one recently killed; and still less if the skin has been taken off. We get all cats from the pound.

As to dissecting, which seems to be the one feature to which Dr Linville and Mr Peabody object, I hardly think we can say that it is impracticable; because I know of one school at least in which it has been done for the last 18 years. My predecessor carried it on for four years, I for four more, and my successors have done so for the past 10 years, and they are still dissecting.

Now with reference to the length of this outlined course, specially the 20 weeks course, because it is quite unlikely that we shall soon have a year of work in zoology. I wrote a few days ago to the instructor in biology in the central high school of Detroit, asking him for all the criticisms which he could suggest to the proposed course. I told Mr Murbach that I thought it quite possible that our course could not be put into operation immediately and asked him various direct questions, particularly whether or not his pupils dissected specimens. He said, they make all the dissections necessary to show the internal structure.

That is all the report calls for in any dissection. I asked him farther about the list of specimens which we propose for the 20 weeks course; and he replied that it is practically the same as theirs, so nearly that it is useless to point out exceptions. Evidently he does not consider it too long. All the animals mentioned in the 20 weeks course ought to be found within one and one half or two miles of any high school in the state, unless it may be in New York city. There is only one exception, the starfish, and this is only one specimen in the 20 weeks course. All live in fresh water or else in the fields or woods. I think it entirely possible for all teachers to get material without great trouble, and that is all you need — the material to study and a student to teach from this material. The greatest desideratum is the teacher, because no matter how many students there are or how much material is available, the work can not be done without a well equipped teacher. Teachers are said to have all they can do, and more, with their present work. If that is so, I do not think they ought to be asked to undertake this; if they are so overtasked, they ought to have some one to help. But that is a question for school boards to settle. The person who is to teach zoology must have equipment and training. It is not difficult now to get training in zoology. Three or four summer schools are carried on in this state or within very easy access from any point in the state, and, not only that, there are two or three marine laboratories easily accessible. There are one or two fresh water laboratories along the lakes to which teachers are welcomed. There are at least a score of laboratory books which a teacher can use and get a very fair knowledge of the habits and structure of all the forms mentioned in the report, because they are all common forms. We have a right to expect preparation from the teacher of zoology, just as much as a school board has a right to expect proper training in the teacher of any subject; and as an association we ought to insist on this point.

This is not in all essential particulars an ideal course. I am told that it is in practical operation in Detroit, Milwaukee and

Washington; and, judging from a collection of reports of boards of education and high schools and so on, which I looked over a few weeks ago in the high school in Rochester, I could find in the United States more than a dozen schools in which practically this kind of work is done. If other teachers can do it New York teachers can.

I do not believe that the committee ought to expect, or do expect that this is going to be put into immediate operation in any of the schools unless they have a special teacher for the subject. Our aim is just the aim of the committee in physics or the committee in botany, viz to arrange a course which ought to be worked up to. Some schools are doing it and others can do it or come very near to it.

The only thing in equipment which is at all expensive is the microscope. I think I am right in saying that the regents will pay half the cost of a microscope. You can get one for $25 and should be able to pay $12.50. It should be used not only in zoology but in physics and physiology. It can be used in various departments. It is not a luxury but a necessity. It is perfectly possible to carry on good scientific work without any microscope at all, but you will have to omit some of the work on the lower, simpler organisms.

## Section B. CHEMISTRY AND PHYSICS

### REPORT OF THE SUBCOMMITTEE OF THE COMMITTEE OF NINE

### The secondary school course in chemistry

BY PROF. E. W. WETMORE, STATE NORMAL COLLEGE

Before entering on the immediate duty of the hour, it will not be improper perhaps for me to say a word in explanation of my appearing here this afternoon. I was not selected for this position in the first place and therefore I feel to a certain extent like an interloper. On that account I crave your indulgence. The gentleman who was to be the chairman of this section is Prof. Lyon of Oneonta, whom I have had the pleasure of visiting quite frequently in the past few weeks, and it may be of interest to you to know of the experience which has compelled his absence.

Some two years ago he became very much interested — and has been ever since — in the matter of X-rays. In prosecution of his investigations and in preparing for a lecture which he was to give on the subject, he took an X-ray picture of his knee. As he wanted to get a particularly fine one, he used his most powerful instrument, his most powerful current, and put it down very close to his knee. He got a good picture, but he got something else besides and that was a burn. He realized it only as a slight blister and noticed that a small portion of the skin came off, but thought nothing farther about it at the time. A short while ago he fell and struck his knee, knocking the skin off, and immediately a most malignant ulcer set in. The surgeon in Oneonta said that it was beyond him altogether and he would have to go to the Albany hospital. He did so and has been there some weeks and, I fear, is likely to be there under treatment for some weeks still. It is a most peculiar case. It would not slough, it obstinately refused to do that, but a portion of flesh under it has hardened and become lifeless, till, as he described it to me, it is just about the consistency of white cartilage which one finds in a cut of rib roast — perfectly white, highly elastic, no life in it. The physicians find it difficult to do anything with it. They do not dare to cut it out on account of its location near the lubricating sacs and they are in a great deal of anxiety in regard to it; but he hopes that they have stopped its advancement. It is a very curious and interesting case. The man who is suffering sends his kindest regards to you all, collectively and individually, is feeling cheerful and wishes he could be here — and from the bottom of my heart I wish he were.

I have been requested to present to you as a part of my duty this afternoon the report of the subcommittee of the committee of nine on "The secondary school course in chemistry." Perhaps I hardly need to say that no report of this kind, which is a sort of a composite photograph of the opinions of a number of persons, represents exactly the ideas of any one person. I suppose that every individual on the committee would modify this to a considerable extent if he had his own way.

[The report appears as a part of the report of the committee of nine, on p. 708.]

In connection with the report, after consultation with Dr Cooley, I take the liberty of suggesting certain questions that arise and, without attempting to force these questions on you or to insist that they are the ones that shall be discussed, I will read them.

1 Shall the recommendation of the Science teachers association be an ideal course in chemistry, or one deemed practicable of adoption by ordinary schools?

2 Should some instruction in organic chemistry be a part of every high school course?

3 Should chemical formulas and equations be approached through the quantitative laws or directly through the presentation of atomic constitution?

4 Should the theoretic part of chemistry be taught consecutively and in logical order or each point be made clear early in the course and whenever it may be indicated in the prosecution of practical work?

5 What are the essential and what the desirable topics of theoretic chemistry to be taught in a scheme of general education?

6 Can any of the subject-matter recommended in the report be profitably omitted?

**Prof. R. H. Cornish** — Prof. Woodhull, in his paper read this morning, presented a course in chemistry and urged its adoption as the first year course in science for the high school. If Prof. Woodhull's plan were adopted, I should like to inquire, how would the interesting report on chemistry now under discussion fit in with his plan? It seems to me that the course now before us is intended for pupils of the third or fourth year of the high school, that is, for pupils of considerable maturity. I do not see how the work outlined could be done in less than a year, or profitably with pupils below the third year.

**Prin. T. B. Stowell** — I would like to have these gentlemen who are experienced in teaching give their judgments as to the practicability of following the course outlined. I am prepared to say that I can do it. I should change the order of some of the topics, because the work is observational and one subject should grow out of another. Cover all the ground recommended and the children will keep clear on the subject-matter. It looks like a great task to one who is not familiar with it, but, when one subject grows out of the one preceding, it is not such a big affair after all. I do not think the course too hard for pupils in the first year or the second year or the third year of the high school. In the paper read before the section this forenoon, you have my judgment of this whole matter of sequence. I now contend that we should come to some agreement. I will abandon any scheme that I have advocated if we can agree. Last year I yielded because it seemed that we could get the convention to adopt physics. I am ready to yield again. If we are guided by the report of the committee presented last night, chemistry is a fourth year optional study and biology is to follow it. How much biology are you going to get in a course that follows an optional fourth year study?

**Prof. Albert L. Arey** — I would say that the committee proposed this course as a fourth year course and not for the first year as suggested by Prof. Woodhull. We believe that, if chemistry is to be taught in the high school, it should be taught so that it will be received for college entrance, and I fear that first year chemistry would not be accepted.

**Prof. H. J. Schmitz** — I think the outline a very good one. I have followed it attentively and wish to commend it in one regard particularly, that it develops the different laws from facts that the student has learned. This is the only natural way. I know in the way in which chemistry was formerly taught, nothing was understood; and it would seem that some facts should be taught first from which we can deduce laws later on, but whether we begin with oxygen or hydrogen does not make any difference. The outline is excellent, and I should very much like to see it adopted. It seems to me that the material is sufficient; that the method employed develops laws from the facts which have been presented.

**Prof. E. W. Wetmore** — I can give some experience with reference to such a course. I myself have taught — at a time in past years when I was engaged in high school work — a high school class in a place in which I could not get a laboratory, so that whatever was done had to be done in class. I have covered all the ground that is outlined in this report and in addition to that a considerable amount of organic chemistry in one half year, and, when we got through with it, the pupils could pass a good examination, but it was fourth year high school work.

**Prin. T. B. Stowell** — In this connection do we not make a grave mistake? Do you realize that you can effect in your second high school year better work than the college professor can with his freshmen? Such is the fact. If you have had your high school pupils with you and they know you and their surroundings, there is nothing to distract; they know what is going to happen and can concentrate their energies on the task in hand. They go to college, they recite to a strange professor, their surroundings are strange, every thing is strange, and the mind will not act with its wonted vigor. To my mind this is not a question of the first year or of the second year. From frequent conversations with science teachers in colleges and universities I am convinced that there are considerations other than time. I have done work in my classes three years before college entrance that college professors have told me they could not do with freshmen; and college professors are men of no mean ability. I am satisfied that the work outlined can be done in the first year of the high school. Whether you want it in the first year is another question.

**Prof. I. P. Bishop** — I regret that I arrived here too late to hear the whole of his interesting paper, but hope I may be pardoned if I say a few words regarding the order in which chemistry and physics should come in the course. These subjects are so related that often a knowledge of one necessarily involves some acquaintance with the other. For example, to understand chemistry it is essential that the pupil know something of the nature of heat and the properties of fluids. So in physics, a little knowledge of chemistry helps to a clearer insight into the mysteries of a galvanic battery. I do not suppose any hard and fast rule exists by which we can always decide the order of precedence. If we teach one of these before the other, it should be for a good reason. Either the first subject should throw light on the subsequent one, making it easier of comprehension, or it should be better adapted to the child's mind. To me chemistry seems the more elementary. Physics requires more maturity of thought and reasoning power. And, though Prof. Bardwell reports that a large number of teachers prefer to place physics before chemistry, I do not believe that he would give that as his own choice. In fact, I am quite sure that a majority of the normal school science teachers would agree that the facts of chemistry are more easily grasped, that they furnish better sense training, and that the associated laboratory work affords better preliminary drill in handling apparatus. Therefore, I hold that logically chemistry precedes. Another reason is found in the fact that chemical apparatus for individual work costs less than half as much as a corresponding outfit for physics, and it would be easier to begin with a good chemical than a good physical laboratory. If, however, the exigencies of the case compel the teacher to place physics first, no serious harm will be done. I merely wish to say that I have tried both ways and get the best results when chemistry precedes.

I see nothing in the proposed course too difficult for first year students, though I prefer to put chemistry in the second or third year and let it be followed by physics.

——— What do you think of the suggestion of having physics and chemistry run parallel to one another?

**Prof. I. P. Bishop** — If you put them together, you give the student too heavy a load of science, and in my judgment that is not advisable.

——— Some one asked if any one knew of a school where the subjects of chemistry and physics were taught together or mixed. I know of such a school where I was a teacher. Physics was taught the first term, chemistry the second term, and physics again the third term. That was considered only a very elementary course preparatory to higher work. We ought to keep in mind that a large majority of high school pupils never go to college; and, instead of spending too much time on the metals, they ought to learn something of what an alcohol is — that there is a group we call alcohol, having certain common properties. They ought to know something about the acids and a few of the elementary substances in organic chemistry that they are bound to meet with every day after they go out into the world; also the subject of fermentation; and we make a great mistake if we do not teach a little organic chemistry in connection with carbon.

**Prof. W. H. Snyder** — It happens that I have been chairman of a committee of the Eastern association of chemistry teachers for getting out a course in high school chemistry, and this seems to be along that line. We have met with a good deal of difficulty in trying to formulate our views on the subject, from the fact that in any high school there are two very distinct tendencies to be met. Harvard college takes one ground and the Massachusetts institute of technology and almost all the colleges take another. It is almost impossible for us to bring out any course that will fit these two. It has been said that no man can train a class of boys that will be prepared to enter Harvard college and enter anywhere else on the face of the earth. What Harvard desires is more quantitative work. Prof. Richards insists that a boy shall have no reference to any book or treatise on chemistry, but shall be put into the laboratory with a balance and plenty of other apparatus and shall work out a number of the laws of chemistry in fairly good shape. The work is almost entirely quantitative and some of it exceptionally good. I think I may say for Prof. Richards's scheme that the first part of it is the most successful we have ever tried. It deals with the composition of salt, the composition of limestone, the composition of nitric acid. These are so treated that, with a good deal of reasoning on the part of the teacher, the boy can be made to understand what he is about and what he is in the laboratory for. He gets more of an idea of what science really is than by any other course I have seen. If, as has been said by one of the speakers here today, this association can bring anything to bear as a lever, I do not care how long the fulcrum, if it will lift up chemistry so that there will be any unanimity of opinion as to what shall be done, so that a man will not have to do one thing for one place and another thing for another place, it will have done a real service. We need it badly enough. Probably there is no other subject in which the teaching is so diversified and has so little central aim and purpose as that in chemistry. Whether the course outlined here is the best I myself am a little in doubt. Every man has a course which he thinks is better than any other. It seems to me that more quantitative work can be put in, that there is not quite as much need of the study of the gases as has been indicated here, and perhaps the order and sequence could be differently arranged.

**Prof. H. J. Schmitz** — I have an idea perhaps a little different from this in regard to secondary school education. I would like to ask what is the purpose of the secondary schools? I learn here that it is simply to prepare students for college. Where does the education come in? Are we here to discuss the teaching of science simply for entrance to college? Are there no children that are to be prepared for something else? Has science no other claim? I should like to hear a discussion on the teaching of science for the education of the people. I want science taught in the schools, not as a requirement for college, but for its educational value. Science can be taught with a higher object than simply making easier the work of the college teacher. What is the college to do? If the secondary school is to do all the work, then let us call the secondary school a college. But the secondary school has a specific function, to lay a broad foundation for life as a whole; and the teaching of science in the secondary school ought to be a preparation for life in general and not be made a question of regents counts or college entrance requirements. Therefore I protest against the teaching of science in the secondary schools simply with reference to what the colleges demand. Have it considered a part of a necessary education.

**Prof. E. S. Babcock** — I heartily approve the course recommended by the committee. It seems to me that, if it is not as full as some may desire, it is an exceedingly good report. If a teacher wishes to specialize along any particular line, room and time are given in which to do so in addition to doing what has been recommended. The report however covers finely a course that can be pursued. As regards the possibility of doing this work, I wish to say that in an experience of about seven years I have been able to do as much as the report recommends and a little more with students in the third or fourth year. I have met with but one failure in this respect and that was when I tried to get up a little enthusiasm on the part of some left-overs.

——— What is your idea in regard to the question of organic chemistry?

**Prof. E. S. Babcock** — I should prefer to do very little with it, but there is no reason why a teacher may not do some work in organic chemistry if he so desire.

**Prof. W. H. Snyder** — My view is that it is good to have a little organic chemistry in the course, particularly if boys are not going to college. It is my opinion that the putting in of a little organic chemistry, just a few of the most simple experiments and fundamental relations, is good at the end of the course.

**Prof. H. J. Schmitz** — To my mind, the question we want to consider for a moment is, what are we studying chemistry for? Is chemistry to be taken as a part of education, to train the reasoning powers, or is it to be simply instructive, it is to be preparatory to college? Is every secondary school in the state to be a college preparatory school? Are we going to have no education different from preliminary instruction for the colleges of this country? The college side ought to be something definite and settled, and we ought to regard a course of study for the secondary school as something that has to do with education, not simply with instruction or with preparation for college. I should like to hear that point discussed. I suspect that we are mixing different points of view.

**Prof. E. W. Wetmore** — We all know the ground which Pres. Eliot has taken, that the education for the one who will not go to college should be the same as for the one who will go; that there should be a broad and wise development for all up to that stage and that the college is to take the student then and develop him still farther. I think that ground is well taken by Pres. Eliot; and that those who are most in touch with the pupils of secondary schools and are familiar with their needs, as one who has entered the higher and rarer atmosphere of the university can not be, should be the persons to determine the preparatory development. We acknowledge the higher mental ability of the college professors, and of such men as Pres. Eliot, Pres. Schurman and Pres. Adams. We do not put ourselves on the same plane with them in that respect; but I do insist that we who are engaged with young people in secondary education, coming in contact with them from day to day, stand on better ground for knowing their needs and knowing what is the best development for them at a certain age, than those who occupy the higher plane. It is a well known fact that the advanced expert in mathematics is as a rule the poorest teacher of *elementary* mathematics, because he does not appreciate the difficulties of the beginner. It is a well known fact that the expert in chemistry is apt to be the poorest teacher of elementary chemistry; and, when I say expert, I mean one who has gotten so far beyond the elements, who is so thoroughly familiar with the commonest things that his interests are engaged with the big things, the odd things, the advanced things. The very frame of mind that puts him in touch with these things puts him out of sympathy with the beginner. It is very rare that a college professor can tell a good story to the child in a kindergarten. Why? Because his frame of mind is different; he is in contact with different things altogether. The kindergarten teacher excels him every time in handling little children. Why? Because she is in constant touch with little children, and learns to think as they think and so to know their needs. That question will never be wisely settled till the colleges are willing to consult with the secondary teachers, even to defer to their judgment as to what the pupils need. The university should not establish the entire course and say what shall be done, but the foundation should be laid by those who are best competent to judge what that foundation should be, viz the secondary teachers and students of child nature. When these have agreed as to the line of demarcation at which secondary education, which is to fit most young men and women for life, shall end, let the colleges and universities take those that come to them and fit them for the higher walks.

**Prof. W. A. Brownell** — I know that in many schools but six months' time is allowed to chemistry, and more could not be put in without an entire disarrangement of their programs. I wish therefore to know whether it is the thought that there shall be no teaching of chemistry unless it be for a full year. That was a matter of very earnest discussion at the principals conference yesterday, and as a result the original proposition was modified so as to state that it is in the highest degree desirable that chemistry shall receive a year. That does not imply that, in case a school could not come up to the point of giving a full year, the committee or the association would therefore say, either have a whole year or do not have it at all, but that it is highly desirable where this can be done to have it for that time. If this can be done, it is an ideal course. I do not think that a majority of the schools can or will adopt such a course, and I do not think the regents should require it as the basis of their examinations. It is truly an ideal course in the sense that it is not a course that could at present be carried out in the schools of the state. Many schools would naturally be unable to follow such a course rigidly. But the idea so far as I have been able to ascertain it, is that we should emphasize the idea of the committee as to what a course should be. It is intended to be so flexible that the individuality of the teacher can have play, and that the course can be adapted to a particular school, its facilities and its environment. As far as a school is able to teach chemistry at all, it should follow the lines which are pointed out there with reference to the topics, the methods of teaching and the results which are sought. The subject-matter need not necessarily follow the particular order laid down there; the arrangement of topics is a matter of minor consideration, as for instance whether oxygen should precede hydrogen or whether water should precede both. But the general line of work should be in accord with the principles laid down in the report, and in that sense it is a practical course. The schools, I think, should work toward that ideal. We believe that there are many schools in New York state, we know that there are many schools in other states, which are doing well even more than that outline requires. But what these best schools are doing now is far more than the same schools could have done a few years ago.

They have been working toward an ideal and have come fully up to it. I believe that setting up this ideal before the schools will improve their methods, and therefore do a good work not only for secondary education but for science as well. That, I judge, is the way the committee felt as to this report.

**Prof. E. L. Nichols** — In my judgment, the value of this sort of report lies in indicating the consensus of opinion of our committee and of this association as to what a school may hope to accomplish. In adopting or in any way approving such a report we ought to make it, in the interests of science teaching, perfectly clear that we are not after a manufactured or imitation article in chemistry or in physics, but that we wish to see the individuality of each teacher brought out to the fullest degree. I am beginning to feel very timid with reference to the whole procedure that has been going on among science teachers of late years in this respect, lest a few shall in some way bind, not intentionally perhaps, the freedom of science teachers in the schools in a way that can only be harmful; and I think that some disclaimer of any intention to do that should go into the report.

**Mrs C. E. Pingrey** — Is this course of study intended for a year? Do I understand that at the present time the regents requirement for a year is less than that? It seems to me that the regents require more and that in a year's time we cover more ground than that.

**Prof. LeRoy C. Cooley** — It should be remembered in regard to that particular point, that laboratory work is a slow and somewhat tedious process; that the ground covered by a course involving laboratory work must be much more narrow and less extended than may be covered if the lecture and textbook methods alone are used. Now the present requirements of the regents, as I understand them, do not include laboratory work, whereas the effort of this committee, and I believe the tendency of all science teachers at the present time, is to make science a laboratory study. This is preeminently true in chemistry and physics. If this proposed course does not cover as much ground as other courses hitherto prescribed, it should be attributed to the fact that much thorough laboratory study is included. A course in chemistry must cover less ground if laboratory work is made an integral part of it than if it involves only the study of textbooks. In my opinion the amount of laboratory work involved in this proposed course, if done in the thoughtful and thorough way contemplated by the committee, and in connection with lectures and textbook study, may require more than a year, instead of less, for the average pupil in the average school. It may be extended or curtailed without changing its spirit or its methods.

**Prof. E. W. Wetmore** — I would say that this report specifically declares against assigning so much of subject-matter as is and has been very often taught, for the very reason of the greater amount of time and thought required and of the slower progress of the work that has to be done in developing these things if the laboratory method be followed.

**Mrs C. E. Pingrey** — I heartily sustain that report, but so long as we have to cover the amount we do in a year's time, we can not do laboratory work.

——— I would simply add this question, whether this is designed for pupils who are in the first year of the high school? It has been said by members of the committee that it is designed for pupils in the fourth year; and I think it might be wise to reduce it a little, so that it can be put in the first year. If any school should wish to put the course in the fourth year, that school could enlarge it for itself. I would leave to the teacher the opportunity to enlarge. I think it wiser that we should be below the maximum than that we should be above it in the case of the average school. One of our friends has said that he can handle this course in one year, and I am sure he can, but he is not the average teacher of the state of New York, and, while it may be a very easy matter for him, that is not the average case. I would emphasize the thought that it might be wise to soften the course a little, so that any school in the state of New York can take it in the first year.

——— I move that this report be adopted as the ideal which all schools shall be expected to reach in the future; and that all schools that can, be urged to enlarge on this report as much as possible.

**Prof. W. H. Snyder** — I hope this association will if possible adopt this report. It is by far the best presented to any association, and I know it will help very much in unifying the subject of chemistry. That is what we need; and there is no body at present, I believe, that can give so much of an incentive as this body. Even if it is not the ideal of each one of us, I sincerely hope something will be done in this line. It is an exceedingly finely planned course and will bring the teaching of chemistry up to a much higher standard than the present.

The report of the committee was adopted.

## The secondary school course in physics

BY PROF. ALBERT L. AREY, ROCHESTER HIGH SCHOOL

[The report appears as a part of the report of the committee of nine, on p. 728.]

**Prof. G. M. Turner** — It perhaps may not be out of place here to say a word with reference to the report read by Sup't Bardwell yesterday afternoon before the principals conference. It seems to me that the report of our own committees and that of Sup't Bardwell might be taken up together. I think those science men who were present at the meeting yesterday afternoon could scarcely feel gratified at the attitude taken by the principals toward Mr Bardwell's report, specially as it bore on physics and chemistry; and I can hardly feel that it is the wish of the Science teachers association of this state to allow the record of the academic principals to go on file with nothing from this association in the least opposed to the attitude taken by them. Those who were present know that the report, so far as physics and chemistry were concerned, was practically discarded; in other words, they put the matter back in the same position, as regards physics and chemistry, that it holds at the present time. If I can judge, it is the wish of all not to hamper in any way the smaller schools of the state, but to lead them up to something higher than they have attained. It seemed to be the feeling of the principals, who spoke yesterday afternoon, that it is the intention of the large schools to crowd out and in some way injure the smaller schools of the state; and I do not want it to go on record unchallenged that this association has any thought of crowding out the smaller schools. We do however desire so to arrange matters with the regents that they will adopt some plan by which the teachers in the smaller schools can have better facilities for work and the work done by these smaller schools shall be better than it now is. I should like to hear some discussion of the subject in order that we may have something in our report in connection with Mr Bardwell's report of yesterday afternoon.

**Prin. C. M. Bean** — There is apparently much misunderstanding in regard to the meeting of yesterday. I do not think the opposition to that report is as great as it seemed to be, but that the matter is not fairly understood. I am in favor of having physics run the whole year, but the objection to the report as it stood was that it made physics a whole year course or nothing, and the effect would have been to force the study out of the schools. Many of the village schools would not start in on that whole year course because it is impossible to hold many of their better pupils a full year. In my school I should prefer to have physics the whole year through if it were practicable. The principals should endeavor not to have half year courses but to make them consecutive, and I think it may be done; but it would have been unwise to pass a resolution yesterday to that effect, for the reason that it would have hampered the physics course in many schools. I favor this report as read today. It outlines what we ought to do and what many of us have been trying to do for many years. I have believed for a long time that physics should be taught if possible in the fourth year of the high school course, possibly in some cases in the third year. It is a subject for mature pupils, fitted by preceding studies to take it up. With that class of students the course outlined would be very successful and would give information and education together, not trying to give one without the other.

**Prof. E. W. Wetmore** — Two years ago before this Science teachers association I gave utterance to this expression — that as an association we should be doing our best work and fulfilling our mission in the highest degree if we kept constantly before us the helping of the smaller and weaker schools and not quite so much what would be exceedingly desirable for the large schools, the well equipped schools with well equipped teachers. The well trained teacher in the large city school can manage to get along without the Science teachers association; he can do very good work without it. He can get helps, suggestions, in a great many ways, but our work should be commoner work if we are going to be good for anything. It should be to help the weaker ones and not to jolly one another along. This is one thing that we need to keep in mind in these reports, in our discussions and in the final recommendations which we shall make. Now, having that in mind, I have noted down after some thought four points on which this section may reasonably take a position.

1 A recommendation to the regents of some practicable plan for the encouragement of laboratory work in physics and chemistry by means of credit given for notebooks of original work; for example, that regents credits be given not for subject-matter of examinations only, but the notebooks properly attested by the teacher be accepted either as the basis of certain additional credits, or in lieu of a certain number of questions, or, better still, to constitute a full separate count.

2 The kind of quantitative laboratory work in physics that can be profitably done in the smaller schools and academies.

3 Increased requirement by teachers of physics of home experimentation and applications to illustrate principles.

4 The practicability for each of our high schools of selecting a major science which shall be pursued one and one half years, the other sciences to be treated as minor courses, each one to receive a half year, the number of minor sciences pursued to be elective on the part of the pupil with the advice of teacher and parent.

I suggest that as a matter of thought. We need in our scientific work more depth somewhere. There has been too much of this everlasting scattering all over nature, and there has been so much scattering in our educational system that there is no depth in anything. Life is not long enough to dig deep artesian wells in every subject, and there is only one course that will give good results; that is to have groups of studies and then out of these groups select a study which shall be the major study, and to that study give time enough to accomplish something. To do that takes time, and it can not be done by dabbling a little in physics, a little in botany, etc.— that gives breadth but no depth. The only way to master the scientific method is to pursue one thing, and I believe that can not be done well in less than a year and a half, half a year of getting ready — observational work, superficial, if you choose, learning how to observe, and then a solid year of study of the subject as a science. Let the study of the other sciences be a mere opening of the doors, so that, when the pupils want to get information, they will know where to seek it. It does not make any difference which one is taken in a particular high school so long as one is taken. Let the science selected be according to the predilections of the teacher, the equipment of the school, its location, or according to any of those circumstances which may suggest it as the leading study; but let us have the pupils know something. My observation is that precious few of them know anything, and they come to us from all over the state. There are certain schools the pupils from which, I am always confident, are going to know something, and there are certain schools the pupils from which, I am sure beforehand, will not know anything. I think that it would be wise, if we could agree on some plan and get a recommendation that would lead toward thoroughness in something.

**Prof. E. L. Nichols** — This idea of giving credit for notebooks in physics is a good one, and I should be inclined to enlarge it and say notebooks of all kinds. I should like to have the association, today if possible, urge on the regents some plan by which this can be done; and we should likewise urge this point, that their present physics requirement really covers too much ground and might well be concentrated a little, as by covering less ground more could be done on certain important topics. I move that the Science teachers association ask the regents to consider a plan for granting credit for properly accredited notebooks in laboratory physics.

**Prof. G. M. Turner** — I did not mean, in my remarks a few moments ago, to criticize the student who attends a school for a half year. I do object to putting in the program a half year's work; to putting an examination at the end of the half year, because it would give the pupil the impression that he has completed something; whereas he has not, any more than a pupil who has gone through his Latin grammar. If a pupil wishes to come in and do work for half a year, well and good. But should he receive any regents credit for it? I say no. The course should be a year course, and things should point toward a year course in the smaller school as well as in the large school. If he can not stay through the time period, very well; but credit should not be given till he has finished a course that means something. I think it was a part of the report yesterday afternoon that the work in physics should not be so specifically laid down; that notebooks should be used and these notebooks might take different forms in different schools; that there should be freedom for each teacher, depending on his equipment, to make special preparation, one in heat, another in electricity, etc.; that the course as laid down should be so elastic that the teacher will have the liberty of swinging out into lines best adapted for his individual work.

——— I am impressed with the idea that we are trying to do too much. My duties for many years have brought me into close contact with all departments of school work from the kindergarten up through the high school, and I believe that too much work is crowded into the various departments. There is a year of study in Latin or in Greek or in German, and a year of study in algebra and in geometry; yesterday I heard, and approved, the opinion that there should be a year in United States history; and it was declared that ancient history is important enough to claim a year. Now I hear that we are to give a year to the study of chemistry, and, as I think of it apart from the rest of the course, it seems just right; and a year to the study of physics seems desirable, if physics be considered apart from the other branches of the course. I think that some of these considerations appealed to the principals and perhaps caused the action to which allusion has just been made. How can we accomplish so much, even with those who are in the classical department and preparing for college? In the ordinary schools of the state, where pupils come from the farm and receive a benefit that will tell in future usefulness, students coming in November and leaving in March can not complete the whole of the work that is required. As I walked through this institution and saw the apparatus, I was amazed at the amount of it; and, when I think of the small amount of apparatus, comparatively speaking, used in most of the schools, not in our cities but in the larger villages of the state, I wonder that they do as good work as they do. I was impressed with another thought, that we are not dependent altogether on costly apparatus; that many principles, particularly in physics, can be explained by apparatus which the pupils themselves may provide. The principles of motion around a center can be demonstrated with a string and the ready fingers; and with the same bit of apparatus the friction in machinery can be demonstrated; two bottles which any one can find at home, one of moderate size and one smaller, may illustrate principles pertaining to the pressure of liquids; and the expansion and contraction of air can be demonstrated by simple apparatus which the pupils can get at their homes. I believe in thoroughness, but I believe that our courses must be shortened very much, as indicated by our chairman, giving prominence to physics or chemistry, with less careful consideration of other subjects, in order that there may be depth rather than superficiality.

**Prof. O. C. Kenyon** — I heartily agree with the report of the committee in general, and am also heartily in favor of Dr Nichols's motion that notebooks be submitted to the regents and credit be given for them. That is an end toward which I have been looking for a number of years. I have myself offered to pay the expense of having the books examined, if that would bring about the result. We are prepared and have been prepared for six years to do this laboratory work, and it is desirable that schools that are ready shall be encouraged to do it and receive credit for it. I suppose that the regents have been ashamed of their course in physics and surely we all ought to be ashamed of the manner in which the study has been and is being taught in this state. The sooner some practicable method in this matter is adopted, the better it will be for all. We are behind the other states, and it is time we took a step forward in regard to laboratory work. I think I perceive the difficulty of the regents. The schools throughout the state are not equally prepared. I do not see, myself, how a teacher in a union school, having perhaps a dozen studies to teach, can have any first-class laboratory work. I have been such a teacher and know what it means. The regents can not require of these schools many quantitative experiments. If they do, it will shut out even the small amount of scientific work done in them at present. But schools that are prepared, ought to be allowed to teach real physics, even if the number of such schools is not large. Three years ago at a meeting of this association, the intimation was made by Inspector Cobb that, when 10 schools in the state were prepared to do this work, they would be allowed to take it up, and get credit for it; but the regents seem to have changed their mind, because I was afterward told that they could not carry out this plan. Some schools are not prepared to do the work and some are; then let those that are able to do it present their notebooks to the regents and receive credit for them.

——— We can blame ourselves in a good many schools if we do not have apparatus for these experiments. In certain lines in physics the experiments can be performed by very inexpensive apparatus; in any school, I believe, the apparatus could be provided; and every union school teacher could find time for experimentation along certain lines. I know something about his duties, but I believe that, if he was going to have a class in physics, he could find the time somehow, after school perhaps, to do this work, with the idea that credit would certainly be given for it. It is easy to get a student to work with a definite end in view. There is benefit in working along certain lines of experiment. The educational advantage would be as great if all the experiments related to one topic as if they were scattered over all the topics in physics.

**Prof. H. L. F. Morse** — I wish to place the Troy high school on record as favoring this report. We have been doing this work, and there must be 10 schools that have sufficient apparatus. I am heartily in favor of Prof. Nichols's motion that recognition of some sort be given to the schools that are ready to do this work.

**Prin. T. B. Lovell** — I beg leave to say that, though the regents have not given any credit for notebooks, I have had this experience in my own school — an inspector going into the classroom of the teacher in science, listening to the recitation, asking for and examining the notebooks, and commending what was found in them. I think, when this syllabus is revised, there will be a demand for notebooks.

**Inspector C. N. Cobb** — I wish to say in the first place that I think my friend, Prof. Kenyon, slightly misunderstood, perhaps, what was said three years ago or more. What we did say was that, when 10 schools united in asking for an examination, we would consider it, not that we would give it. We will consider it and we will give it if we find it feasible. Then another thing. I want to remind this body that five years ago, when the present syllabus was prepared and adopted, it represented the general consensus of opinion of the best teachers in this state and in other states, and what was feasible and could be done in the schools of the state. It was very largely wrought out by Prof. Woodhull, of the Teachers college, and I think you will all agree with me that he is about as advanced in his ideas on the teaching of science as most of us. Because of the fact that you would not desire us to make changes frequently, we have pledged ourselves to stand by that syllabus for a period of five years. I think it is true without a doubt that we shall arrange in some way to give credit for the laboratory work and for the notebooks. I do not yet know just how we are going to do it, but I have every confidence that we shall do it in some way.

There is another point worthy of our consideration, that is the assertion just made, that this state is behind all the others. I do not believe that at all, and I base my belief on what has been told me by teachers in the other states and on my observation. It has been my fortune to visit the schools in this state quite extensively for a number of years. I have visited the schools in other states to a very limited extent, but at one time or another, I have had the privilege of coming into contact with teachers in the schools in all the states of the Union. I was forcibly reminded of this at the meeting at Trenton the day after Thanksgiving of this year, when the colleges and preparatory schools of the middle states and Maryland were in convention. There it was repeatedly said to me by teachers from other states that they wished they had as good schools as we have; they wished their courses were as good as ours; they wished they could have the assistance that this state is giving to the schools to equip them with apparatus for laboratory work. I want to remind you that this state in paying one half the expense of equipping your laboratories in physics and chemistry, and half a dozen of us are going around all the time, urging you and your boards of education to buy the necessary apparatus and arrange matters so that you can do laboratory work, and agreeing to pay one half the expense of it. I think the regents are doing considerable in this matter of laboratory work.

Then it has been suggested that the present syllabus does not look toward laboratory work. I want to suggest that those of you who feel that way have not read the syllabus. Now, when you go home, sit down and read the syllabus and perhaps you will learn something. You will learn that we very definitely and explicity urge you to do laboratory work, and say that the idea which we have in mind is that this work shall be done in a laboratory fashion. Perhaps we have erred in outlining too long a course to be accomplished in that way. Possibly we have; but then that is because our schools are better than those in other states, and ours can do it while theirs can not.

**Prof. E. L. Nichols** — It would appear that the difference between the large school and the small school in the matter of science teaching is not really very great. The difficulties in science teaching, by which I mean laboratory teaching, increase very rapidly with the size of the class. A very small class does not require the same equipment and tools by any means that it is necessary to furnish for a very large one. The apparatus has to be duplicated and the matter becomes more and more complicated as the size of the class increases. If you demand a cast iron curriculum in your laboratory work, you do of course require a relatively larger amount of apparatus in your small schools than if you give liberty, indicating what the character of the work is to be and leaving it to the individual teacher to work out as he may the details. Any teacher who knows his physics ought to be able to give as good laboratory instruction as is given in any other study, and it is really much easier to provide for half a dozen or a dozen than it is for 50 or for 300. It demands less executive ability, but it does require a knowledge of the subject.

**Prof. I. P. Bishop** — The matter of the necessity and use of the notebook came up and was discussed in one of the sections last year; and I am pleased to know that the conclusions reached then meet with such hearty support today. This association has been concentrating effort on the subject of physics for two or three years to the end that certain definite things might be accomplished. One of these was the adoption of longer courses in physics. Developments in this branch have been so rapid that it has outgrown the time allotted to it, the textbook and to a certain extent the teacher. There is now more in the topic of electricity alone than there was in the whole subject of physics when I studied it, an increase which has rendered necessary new apparatus and extension of time. A whole year in physics is desirable — is absolutely necessary if all topics are to be studied. Laboratory work ought to be required and the submission of the original notes should be obligatory. It would greatly enhance the value of the notes if some general plan of making records were followed. Many notebooks presented by pupils entering the Buffalo normal school are practically worthless because the essential facts have not been recorded.

**Prin. C. W. Richards** — I would like to ask the gentleman if he would put the examination in both June and January if it covered the whole subject.

——— That, I think, was considered yesterday, and the purpose was to have an examination both in January and at the end of the year, but it was to cover a year's work whenever taken.

——— Am I to understand that we shall not have an examination on the first part, and that there is to be no chance for these schools, quite numerous at least in my section, that have students for only 20 weeks, who can not cover the year's work and pass an examination on it? They come in for 20 weeks and then go out to work. It was said yesterday that some of the best students in our state come from schools of that kind. Some of our best teachers have had to work their way through school. Shall we exclude such students from the chance of 20 weeks' study for the sake of the schools that can do 40 weeks' work? Why not let those that can do 40 weeks' work do 20 weeks' work and get credit for it, and then do the other 20, getting credit for that also?

——— It seems to me we insist on one thing yesterday and another today. I do not know to what extent the principals are teachers of science, but I suspect that to a very great extent they are not. Whether they are or not, the teachers in science ought to agree with the principals of the schools. Yesterday this matter was thoroughly discussed, and, as I understand it, the report of the committee was that a year's course be prescribed and the examination cover the whole year. The associated principals voted by a large majority to ask the regents to retain the present system of two examinations, one at the end of part 1 and one at the end of part 2.

**Mrs C. E. Pingrey** — I can not commend this recommendation at all. I presume there are many other teachers struggling as I am to build up a scientific department, and I want to have just as many take these subjects as can take them for half a year or for one full year; but, if there were only a whole year's course, pupils would not take the subject at all. I think they ought to be allowed to take physics half a year and to have an examination at the end of that time.

**Prof. R. J. Kittredge** — It seems to me that we are handling science teaching a little lightly. I should like to see the science department on the same basis that the classical department has occupied so long a time. If in the classical course we require four years of Latin, why should we not require in the science course four years of physics for example? If we require three years of Greek, why not three of chemistry? If we require two of French or two of German or one of each, why not require two years in a science or one year in each of two sciences? That would bring us to the point. Instead of discussing the matter of a year or half a year of physics, why can we not have four years of physics? Then, the matter of examinations. I should be in favor of having examinations every 10 or 20 weeks in all subjects, not as finishing that part at all, but as a drill in examination. Our students are required to take examinations to enter college and examinations for prizes, and for anything in which they receive credit. Why should there not be more examinations as a drill at the conclusion of a definite amount of work?

Once more, can we not fight to place the science department on the same level as that on which the classical department has stood so long?

**Prin. H. T. Skerritt** — I would like to answer the preceding speaker with this thought. The classics are old, well established subjects. We can afford to require four years of Latin and three years of Greek. The sciences are new subjects in many of our schools, and we have difficulty in maintaining large classes in them. We have to urge our students to take science even for six months, and we wish you to take some action in your discussions for building up science work in our schools. By allowing simply one examination at the end of the year, we shall not encourage the study of physics or chemistry in our smaller schools, but shall discourage the study of those subjects; and I think it has been the principle of the regents to give credit for work done. As to the notebooks. If the notebooks contain evidence of careful work, give credit for the notebooks, not necessarily a full year's credit, but credit for, say, 10 weeks' work done. I believe that our boys who come in from the country and study physics for only 20 weeks should before leaving receive credit for 20 weeks' work. We should work toward the ideal one year course and in time we shall reach that heaven, but not "at a single bound."

**Prof. E. W. Wetmore** — You would be surprised, some of you, judging from what has been said this afternoon, if you could know the number of schools in this state taking the first course that they may be said to have studied physics, then shunning the second course because it is difficult and taking something else because they can get the counts easier. Now what it is desired to accomplish by this association and by that resolution is the encouragement of thoroughness in teaching physics. The question is how that will best be accomplished. As it is now, having a first and second course means that a large number of students come from the high schools and academies knowing very little of physics, because they have never studied anything beyond that first course, and have never been instructed in sound, light and electricity; some have not even had heat. They might far better have had these and so been brought into touch with practical, everyday modern life, and never have touched the refinements of pure or molecular mechanics. They are simply doing the things that will give them the greatest number of counts with the least labor, and it is a difficult problem to my mind how to accomplish anything different from that. I do not feel at all clear that the yearly plan would do it.

**Dr H. L. Taylor** — Those students who come to you — do they have Latin?

**Prof. E. W. Wetmore** — I can tell you another thing. In this state and in the United States within the last 10 years there has been an increase of over 100% in the number of students taking Latin and Greek in excess of the increase of population, that is the increase in the number taking those subjects has been very much larger than the increase in population. On the other hand, within the same 10 years, the number of students taking physics and chemistry in this state has gone below the increase in population. Now there is something wrong. It is true in this state and in other states.

**Prin. B. G. Clapp** — I wonder how it would look in the sight of the public if the principals of the high schools met in one place and passed a resolution almost unanimously for a half year examination in physics, and the Science teachers association, made up largely of college men and normal school men, met and passed a resolution that they do not have it, but have a final examination only. The matter was thoroughly discussed yesterday, and the resolution was passed, not unanimously, but by a large majority. I think there is no educational meeting of the year where the principals of the schools are as well represented as in the principals holiday conference. When they pass a resolution almost unanimously asking for half year examinations, and then we come next day to the Science teachers association, made up of college men and normal school men, and pass a resolution not to have half year examinations, I think the regents will be justified in regarding the principals' vote. It is a question that concerns the secondary schools, not so much the normal schools. There is perhaps not a public high school in the state that has the equipment of the normal schools, and you can hardly sympathize with us in the public schools. My judgment is that an examination given when half through physics and another when physics is completed will encourage the teaching of physics in the public schools more than one at the end of the year. We should have two examinations, as we have had. I can see a material difference between physics and Latin. Students commence Latin, and as they advance they are reviewing and becoming stronger, and the farther they go the stronger they become in the primary part of the study. In physics they are obliged to lay aside one after the other mechanics, pneumatics, hydrostatics, hydraulics and heat, and as they approach the discussion of the latter part of the book they forget the first. Furthermore, we have the opinion expressed by the regents five years ago in dividing this examination. They expressed a very positive opinion that it was desirable and there were good reasons for it. Taking all this into consideration, the vote of yesterday should count with the regents instead of the vote of this body.

**Prof. E. S. Babcock** — I have had the fortune to be principal of a very small school, and one point that perhaps would help us in this discussion is this. Those of us who held the March examination for the benefit of pupils who had to leave school, found that these students stayed till June when we discontinued the March examination. This was my experience. It has been intimated that policy should be considered in regard to the matter. Now, if it is a matter of policy that we shall not express our idea on this subject, I might make a motion that we remain silent.

**Prof. T. B. Lovell** — I do not see how the high school teachers are going to settle this matter. The high school teachers have been used to part 1 and part 2. The condition of the schools demands it, and they would naturally vote for the two. I do not know whether we are large enough and broad enough to rise above our environment and vote on this subject. I am not quite certain that the vote will determine the right or wrong of this question.

A motion to lay the matter on the table was lost.

It was voted to recommend to the regents that yearly examinations be given.

**Prof. A. L. Arey** — I move that it be the consensus of this meeting that the report on physics represents an ideal condition toward which all schools should strive.

The motion was carried.

### Thursday evening

## SCIENCE FOR EDUCATION

### BY LEROY C. COOLEY PH. D., VASSAR COLLEGE

The annual meeting of our association is an occasion for reviewing the achievements of the past, taking account of present theories and practices, and perfecting methods for more effective use of science for education in the schools. Not much time should be allotted to looking backward, because so many pressing problems await solution. Nevertheless, the memory of victories inspires courage to attempt higher achievements; and we do well to postpone the consideration of such problems for a time while we review past progress toward their solution.

### Recent progress in pure and applied science

About the middle of this century science entered on a series of unprecedented triumphs. Facts relating to all phases of nature had been accumulating for more than one hundred years when suddenly three remarkable generalizations, on which the three grand divisions of modern science are founded, followed one another in quick succession. In physical science that foundation principle is the conservation of energy. In earth science, it is the persistent uniformity of the methods of nature. In biologic science, it is evolution. Each of these is, in its own province, a guide to research, and at the same time, the touchstone to test the results of investigation. Joule's memorable experiments on energy were published in 1848. Lyell made his first attack on the old catastrophic geology as far back as 1830 but did not assure its defeat till he published the ninth edition of his *Principles of geology* in 1853. And the principle of evolution, which dominates the spirit and methods of biologic science, was enunciated by Darwin in 1859, when his *Origin of species* was published. These three principles came to the front during the years from 1848 to 1859, and their enunciation stamps the middle decade of the 19th century as the most memorable in the history of science.

But we must not stop to read the history of pure and applied science during the eventful half century since that time. As we turn the pages of that history we notice such chapter titles as the following: the atomic theory of matter, the periodic law of the elements, the kinetic theory of gases, the electromagnetic theory of light, the spectroscopic study of the stars, the application of the microscope to the study of the rocks, the culture method in the study of bacteria, the telephone for the transmission of the world's thought and the dynamo for the accomplishment of the world's work. This occasion impels us to pass these attractive titles and fix our thoughts on the use of science in education, a still more remarkable phase of 19th century science.

### School science a modern conception

Science for education is a modern conception. In a few libraries may be found a small octavo volume which contains all the science that was offered a century ago by the best colleges of the world. Of chemistry and physics, of botany and zoology, of geography, meteorology and geology, that little book contains all that was accessible to students. At the beginning of the century there were science courses in Harvard, Yale and Dartmouth only. About that time the first geography was written for the lower schools in America, and it was long afterward that the use of other sciences in the schools was more than dreamed of. From then till now the maintenance of science in the schools has required a constant struggle. In the earlier period it was a *struggle for admission.* In the later period it has been a *struggle for rank*. A few words in regard to each of these phases of progress should be said.

## Struggle for admission

We consider first of all the question: How came science to be recognized as a school study?

De Tocqueville wrote concerning the man of the north as follows: "He has experience as well as knowledge. He however does not care for science as a pleasure and embraces it with avidity only when it leads to practical applications." During the early years of the century there was little science, and still less genuine love of it, among men. But great truths began to emerge from laboratories devoted to research, and labor saving implements from the workshops of inventors. It soon appeared that the study of nature led to ameliorations of social and industrial conditions, and the practical public, as De Tocqueville said it would do in such a case, turned with avidity to science for inspiration and energy in its industrial and social struggles. A widespread interest in applied science created and enforced a demand for the introduction of science teaching into public schools.

This fact accounts for the ugly stamp which was impressed on science teaching in the outset and which the most strenuous efforts have not yet obliterated. The public demanded knowledge instead of education. The public was not able to discriminate between the two. Useful knowledge from attractive sources satisfied the demand; and the educational leaders, without faith in science as a means of mental discipline or culture, made the minimum concession by admitting it to the schools as a purely informational subject. Its reception in public schools soon became well nigh universal, but among educational subjects it was assigned the lowest place. Thenceforth the struggle was not for existence in school programs but for rank among educational subjects.

### Struggle for rank

An educated mind is not a storehouse filled with facts: it is an engine ready for work. Mental energy is more to be desired than knowledge, and the acquisition of knowledge for the sake of mental energy should be the main purpose of education. Furthermore, if education is to be the best for mind and character, its acquirement must not be pursued with a commercial object. That knowledge which the world calls useful is neither an essential agent nor a necessary product of education. The stanchest advocates of science for education have admitted that science for information only is unworthy of a place in the schools, but they have maintained from the outset that, for the symmetric growth of mind and character, science is an indispensable study.

This claim to educational rank was, for a long time, stoutly resisted. At a large and influential educational convention, 20 years ago, a paper was read on "Physical science in public schools" supporting substantially the following thesis:

> Physical science should be taught in schools of every grade, first, because of its peculiar merits as a means of intellectual discipline, and second, because the knowledge and mental habits acquired by the study of it are among the best qualifications for the active duties of life.

These claims met a vigorous opposition. Utility was the only excellence of science that was freely recognized. That a study of nature could impart a mental discipline at all comparable with that imparted by the study of mathematics or the languages was stoutly denied, and this view prevailed in that convention which embodied the most prominent educational influences in the state of New York.

But now after 20 years a truce prevails between the parties to that controversy. Science has strengthened its position in the schools year by year till it is able to demand a considerable fraction of the students' time. Its opponents have recognized the futility of attempts to overthrow it and admit that, for the sake of education, the wisest thing to do is to make the best of it as an educational subject. To this end they ask its advocates to formulate their principles, methods and demands, and await an agreement among scientists on these points.

A few years ago, when six educational conferences were called at Columbia university, there was no conference on science. The omission has been explained on the ground that the opinions of its advocates are so unsettled that the colleges would not be justified in fixing requirements in science. Again: two years ago the Association of colleges and preparatory schools of the middle states and Maryland asked for the present consensus of opinion as to the place of science in the preparatory schools, and set apart a whole session of its annual meeting to learn how the promoters of science would frame the answer. Near the close of the discussion, Pres. Schurman, who, as we all know, has a very warm place in his heart for science teaching, made the following comment: "Our aim, you remember, was to reach a consensus of opinion on the place of science in the secondary schools. I do not know how far you may consider that we have achieved that end. I sometimes think we make less progress than we expect in these gatherings. I recall a story of Lincoln in this connection, that goes back to the civil war. McClellan was commanding the armies and he hovered about the James river when the administration was anxious that he should push on to Richmond, not only as a policy but to crush the confederate forces before they should have time to gather again. Naturally McClellan fell somewhat into disrepute in Washington. One of his friends called on the president and, fearing that he could not say much in favor of the general with reference to the particular campaign in hand, he ventured the statement that McClellan was at least a good engineer. 'Yes,' said Lincoln, 'a stationary engineer.' I sometimes think we are almost in that position." And Pres. Schurman's tone was not hopeful when he added: "But there may be gentlemen or ladies here who can do something more in voicing the consensus of opinion which is presumed to have been reached, on the place of science in the schools."

Such incidents show that opposition to science in the schools is well nigh ended. That science is to share the curriculum with other grand divisions of human knowledge may be regarded as a settled question, and the solicitude of educators in all departments is to know how to make the best of science as an educational subject. The solution of this problem devolves on us but we are not ready to give it.

The physicist alone will never solve the problem, nor the biologist, nor the geologist. Each, admiring most that to which he is most devoted, sees the branches of science in a false perspective. His own branch, by its nearness overshadows all the others. When the several departments will consent to help each other to discuss the great subject of science for education, instead of expending their energies for the promotion of chemistry or zoology or some other branch, it will be possible to indicate the true place of science in the schools.

### Partial analysis of the problem

It seems to me that the general problem consists of two parts:

1 The coordination of science with mathematics, languages and other departments in the secondary schools.

2 The correlation of the several branches which shall constitute the secondary course in science.

On each of these partial problems I venture a few suggestions.

I do not believe that the coordination of science with other departments can be accomplished by simply comparing experiences. It seems to me to involve two investigations.

In the first place, we must recrystallize our ideas of secondary education and secondary school studies. This is necessary because right practices can be most confidently founded on true theories.

In the second place, we must assign to science its specific purposes in the secondary education contemplated by the definitions we construct.

### What is secondary education ?

To how many teachers does secondary education mean much more than that which is given by the schools which stand between the elementary grades and the colleges ? But all such mechanical conceptions of education are practically worthless. Wherever they exist, purely empirical methods of teaching must prevail. It is true that here and there in the schools we find a man or woman who was born a teacher. Such teachers have no use for educational philosophy: they possess the educational instinct and go straight to success. But their number is small, and the great majority of us need a sound theory of education on which to found successful practices. We need to know what secondary education is, before we can rightly use the agencies at our disposal to secure it. Nicholas Murray Butler took a long step toward a complete definition of secondary education in his high school address on the " Scope and functions of secondary education." (*Educational review,* 16: 15)

He finds " the base line from which to measure and lay out the educational course, in the nature of the child-mind and in the character of the studies pursued, rather than in any formal and external scheme of administrative classification." He proceeds to describe the gradual transition of the child-mind from the outset " when its powers are chiefly engaged with sense-perceptions, and directed by imitative instincts, into a period when increased nervous and mental energy mark the years," when new emotions, ambitions and yearnings arise, when introspection begins and a morbid self-consciousness is not infrequent, when the future more and more rivals the present in his thoughts, when old and familiar tasks and games and occupations no longer suffice, when the soul " demands new and more difficult problems to occupy it and to absorb its activities," till at length " the higher thought processes, hitherto latent, exhibit themselves in a variety of ways, and more formal and elaborate chains of inference supersede the reasoning from one particular instance to another that is so characteristic of the little child." And finally, while these new desires and mental processes are forming, the mind gradually rises to a still higher plane, "where its view is more elevated, its scope broader, its methods still more reflective and abstract."

By this analysis Dr Butler makes it appear that, between infancy and manhood, there are three well marked periods of mental growth in which different groups of emotions and thought powers develop in succession.

This fundamental law of mind growth infolds a satisfactory definition of secondary education and suggests the real functions of the secondary schools. It is a standard by which to compare the values of different branches for secondary work, and a guide to their correlation.

According to this principle, elementary education may be defined as general training which involves the acquisition of the simplest elements of knowledge by exercises adapted to develop and coordinate the activities of the child mind in the first period, when sense perception and imitative instincts predominate.

In like manner, secondary education may be defined as general training which involves the acquisition of more and more difficult and complex elements of knowledge by exercises that develop, coordinate and chasten the activities of youth-mind during the second period of mental growth, when efforts toward the higher thought-processes, such as comparison, reflection and judgment, together with more riotous emotions, hopes and aspirations prevail.

The description of a genuine secondary school study is a direct inference from all this. A secondary school study is a branch of knowledge whose subject-matter can stimulate and chasten these new emotions, and whose constituent parts are so logically related that they can supply the most natural and vigorous exercises for these higher thought processes.

We see also, that two things are involved in secondary education — the acquisition of knowledge, and the methods of acquiring it. Of the two I believe that the second is the more important. Said Pres. Leslie, of the American association for the advancement of science, in his inaugural address (1885), "Not how much we know is the best question, but how we got what we know and what we can do with it."

I will now assume, for lack of time to do otherwise, that science will stand the foregoing tests. It is preeminently a secondary school subject. As such it is entitled to a place as honorable as that of any other subject in the curriculum. But it must not be allowed to take a place by usurpation. Its place must be assigned by its aptitudes, determined by the same fundamental law of mind growth which has fixed our definition of secondary education. Its coordination with other departments must be based on its adaptations to definite educational purposes.

### What are the distinctive aptitudes of science for secondary education?

Adaptation of means to ends is not a whit less necessary in training mind than it is in training muscle. The educator should not employ mathematical theorems to train the mind in the processes of inductive reasoning any more than the vocalist should resort to the production or analysis of beautiful colors for the training of the voice. To assign the true place to science in education requires first a candid enumeration of the intellectual processes and emotions which are stimulated in the highest degree by the matter and methods of science study. I do not know that such an enumeration has ever been made by logical procedure. Not that the claims of science have been overlooked; on the contrary, they have been relentlessly pressed, but the pressure has been due sometimes to the affection of the specialist for his subject, and oftentimes to the admiration inspired by the splendid achievements of science, rather than regard for any established principles.

I have ventured to suggest a principle to guide the investigation at this point. It is this: The qualities of mind and character which the lifelong pursuit of science has planted and most highly developed in the men who have done most to promote the growth of science, are those which will be most successfully cultivated by the study of science in the schools.

Starting with this principle, the investigation demands a careful study of the history of science and of the biographies of many scientists. Such an investigation would be expected to reveal the modes of thought, emotions and habits which the serious study of science by right methods is adapted to promote. It would likewise show whether injurious effects on character are not likely to result from excessive devotion to science in the schools and in this direction, also, help to define the boundaries of elementary science teaching.

The details of the investigation would outreach our time on this occasion. What I may say must be illustrative and brief instead of demonstrative and exhaustive.

The sciences of nature are based on observation. The infancy of each was devoted to the accumulation of individual facts, and every stage of its progress required an appeal to objective realities. We find that eminent scientists, under the pressure of this demand, have become the keenest observers. The organs of sense are the only media of communication between the human mind and the external world. The materials of every science have been gathered by the senses, and long continued exercise in this work stimulates the organs of sense to precise action. But what can practice with the organs of sense do toward educating the mind? Is there mental exercise in the simple act of seeing? There may be none, but genuine observation is not seeing alone; it is seeing and thinking combined. In addition to a precise physical action in the organ, observation requires a mental effort by which the sensation is unmistakably attributed to the particular feature of the object which produces it. Observation consists first in the concentration of the mind on the details of special sensations, and second, in the translation of sensations into knowledge of external objects. Observation is therefore a thought power. It is a thought power of supreme importance, inasmuch as by it alone are external objects and events introduced for the contemplation of the mind.

Now in the growth of science this power has been exerted at every stage and it has been most highly developed in those students who have devoted themselves to the study of nature. On this ground we are entitled to say that the study of science in the schools outranks all other studies as a means of fixing the mental habit of keen and exhaustive observation of objects and events.

Next to observation stands comparison. Comparison is an analytic process by which the mind detects likenesses, discovers differences and drops accumulated facts into natural groups. In the growth of no other department of knowledge has this exercise prevailed as it has in that of science. Hence the study of science, if true to the nature of the subject, is adapted, in preeminent degree, to establish the mental habit of confronting fact with fact in order to discover their characteristic features and mutual relationships.

After observation and comparison stands inductive reasoning. This method of reaching truth is exhibited on almost every page of the history of science. Starting from facts and their relationships, investigators have gone by logical steps to the general truths which are called the laws of nature. This is a purely intellectual journey involving many dangers, and nothing but the laws of logic can guide the mind safely from facts to principles. The advancement of science is largely due to inductive reasoning, in which by constant practice investigators have become strong and skilful. Generalization is a mental exercise of the highest order, and, if science teaching is loyal to the methods of science, it will make this a constant exercise of the student at the appropriate place in secondary education.

We must place imagination next in order, because the history of science shows that it is an indispensable servant of the reason in the advancement of science. Emerson defined imagination to be the use which reason makes of the material world (*Addresses and lectures,* 6: 57). It is that which enables the mind to project itself from things seen and known to those which are invisible and unknown. By its aid the reason constructs hypotheses. By imagination hypotheses are cut and polished till the mind is willing to accept them as satisfactory images of the hidden realities of nature. The works of Faraday, Dalton and Draper are filled with exhibitions of vivid imagination. So are the works of all men who have made deep impression on the science of their times. But if the imagination is in constant demand to promote the advancement of science, and if we find it most highly developed in the most successful investigators, then we may know that by the study of science, when rightly directed, the imagination, naturally the wildest of mental powers, may be trained into a docile helpmate of reason.

Patient attention is another thing without which little progress in science has been made. Newton replied to a compliment on his genius: "If I have made any discoveries, it has been owing more to patient attention than to any other talent."

To patient attention we must add clear thinking. Whewell says of Faraday, that he seems to possess the idea of polar forces with the same eminent distinctness with which others possess the idea of the pressure of bodies and adds, "when he can not obtain these distinct modes of conception, he is dissatisfied and conscious of defeat." Phenomena are the symbols in which truths are written, but phenomena abound in superficial likenesses, obscure differences and deceptive analogies. A correct translation of this language requires keen perception, accurate judgment and crystalline forms of expression. Biography shows that these characteristics have been developed in preeminent degrees in the most successful scientists. Hence the elements of clear thinking should be in constant exercise by the student of science.

Finally to patient attention and clear thinking I add *mental rectitude.* The necessity of accepting as truth only that which brings sufficient evidence that it is truth, and of accepting it in opposition to former belief when demonstrated is a lesson taught by the history of all science. That the study of science is competent to establish this mental habit is shown by the fact that the most successful investigators in all ages have acquired it. Dr Chalmers said of Newton: "He wanted no other recommendation for any article of science than the recommendation of evidence and, with this recommendation, he opened to it the chambers of his mind, though authority scowled upon it, and fashion was ashamed of it, and all the beauteous speculations of former days were cruelly broken up by the announcement of the better philosophy and scattered like the fragments of an aerial vision over which the past generations had been slumbering their profound and pleasing reverie. But, on the other hand, should the article of science want the recommendation of evidence, he shut against it all the avenues of his understanding although all antiquity lent their suffrages to it, and all eloquence had thrown around it the most attractive brilliancy, and all habit had incorporated it with every system, and all fancy had arrayed it in graces of the most tempting solicitation, yet was the steady and inflexible mind of Newton proof against this whole weight of authority and allurement and, casting his cold and unwelcoming look at the specious plausibility he rebuked it from his presence."

Such are the aptitudes of science for education. When tested by the facts of history and biography, the sciences are found to be effective agents for the training of mind in: accurate observation, careful comparison, logical inductive reasoning, imagination, patient attention, clear thinking, mental rectitude.

For educating the mind in the first three of these seven processes, science is unrivaled in excellence. For these it may be said to be indispensable; while for training in the last four its value is so great that science ought to go hand in hand with literature, mathematics and philosophy.

But if these are the true functions of science in education, it must be conceded that the true place of science is alongside the other disciplinary subjects all the way from the beginning to the end of the school program of studies. After this concession, there remains only the adjustment of the details of time allotment in order to complete the coordination of science with the long established subjects in the secondary schools.

It seems to me that this problem of coordination outranks all the other serious educational questions relating to the secondary schools.

### Correlation of the sciences

Next to the coordination of science with other departments is the correlation of the branches of science with one another. According to the definition of secondary education (p. 585) different thought powers and emotions come to the front in different stages of mind growth during the secondary period. According to our analysis those which thrive best on the study of science range all the way from the simplest to the most complex. I think it can be shown that the elements of the different grand divisions of science differ in adaptability to these specific purposes. In other words: while all earth science and all biologic and all physical science contain facts and principles which call the highest as well as the lowest powers into action, yet their elementary parts contain them in different proportions, so that one is better adapted than another to the different years of the secondary school. Observation does not prevail in all sciences in equal degrees. Inductive reasoning is a necessity earlier in some sciences than in others. But, if the foundations of one science depend on observation more and inductive reasoning less than those of another, then, by its own nature that science is assigned to the earlier stage in education. We may grant that all branches, in their higher regions, make equal demands on the powers which mature in later periods, without forgetting the fact that in their elementary portions they make unequal demands on those powers which present themselves in succession in the earlier stages of mind growth. Hence the elementary studies of science, at least of the three typical divisions, biologic, physical and earth science, must be wrought into a progressive course, if science teaching is to fulfil its specific purposes in secondary education.

This inference is confirmed by the forms which the courses in the older departments have gradually assumed. What would mathematics have been in education if the algebraists, the geometers and the students of general analysis had never been able to see their favorite branches in true perspective as related parts of a symmetric whole? Why have the dead languages been such living energies in education? First of all because their courses were long since symmetrically arranged, so that step by step they minister to the natural demands of the growing intellect. Why has science in education so far failed to exhibit the power which we know that it possesses? First of all because its purposes have been misapprehended and its methods inadequate; but where these causes are disappearing the failure continues because the better courses in one branch and in another have been constructed independently and are jostling, instead of supporting one another in the schools. We have failed to correlate them. They do not constitute a progressive course in science.

I have no sympathy for specialization in the secondary schools. There will be time enough for specialization after the elements of general science have been mastered. It is early enough to make a specialist after we have educated the man. Men have drawn hard and fast lines between the branches of science but nature has not. The elements of no single branch of science can be mastered without some knowledge of certain others. But the branches of elementary science are not equally dependent on one another; there is a natural sequence of the branches which if embodied in our elementary courses would enable each one to promote the better understanding of that which would follow, and at the same time to supply the demand for exercises adapted to the period of school life to which it was assigned. I plead for science as a department of human thought and action, but not for chemistry, nor physics, not for botany, nor zoology, nor geology except as these are related parts of a symmetric and prolonged course in secondary education.

Reflection on the following considerations has compelled me to regard such a progressive course as indispensable to education, and to science too.

1 The successful study of any science requires a preliminary knowledge of certain elementary facts and principles in others.

2 The pursuit of any science beyond its elements is promoted by the most varied preliminary training in the fundamental scientific methods of study.

3 In subject-matter and methods each elementary science presents a different aspect to the mind and engages the student in exercises peculiar to itself.

4 It follows that the elements of each science may be logically assigned to a special place in a course for secondary education, and that the mastery of the elements of all branches is the best preparation for advanced work in any one.

5 Therefore, in the interests of education and of science too, we ought to adjust the elements of the several divisions of science for a progressive and prolonged course of general education.

But to whom shall we look for the solution of this problem of correlation? Not to the chemist, the biologist, nor the geologist alone, because the views of an expert are sure to be colored by his partiality for his favorite subject. The hearty cooperation of members of all departments is needed. The problem would best be committed to a representative few who, being masters in science, are at the same time competent to deal wisely with educational questions. In such a committee the sciences would stand on common ground where the interests of education might be expected to obscure individual preferences, while the merits of the elementary branches would be faithfully presented, deliberately compared and justly valued.

In my opinion this is one of the most important questions which we have to face just now, and there is no agency better fitted to undertake it than this body of science teachers. Our special subcommittees have formulated the aims, the methods of teaching and the subject-matter of each one of the most prominent high school branches. Through these reports the association has sent out its influences into the classrooms and laboratories in behalf of more intelligent and effective use of each separate high school science. But this is not enough. The sciences share a common responsibility in their work for secondary education; and they need to be skilfully marshalled to meet it. To such a conference as I have described the association could hopefully entrust the problem of the correlation of the elementary branches of science for education in the secondary schools.

### Friday morning, 29 December

### GENERAL SESSION

## EARTH SCIENCE IN SECONDARY SCHOOLS

BY PROF. W. H. SNYDER, WORCESTER (MASS.) ACADEMY

Man's relations in modern society are so complex that almost any subject he pursues will be of use in his attempt to realize the possibilities of life; but a large amount of knowledge must be acquired in order that he may discern his true relations. Since, however, the time which a young man has for study under the most favorable circumstances is limited, he should exercise the greatest care in choice of subjects. It is not sufficient to be able to do one thing well. The bee and the mud-wasp can do that. He must have broad interests and see things in the large. His interests must not be centered in his own community — not even in the one subject that he is investigating in all its details, but rather, as far as he can appreciate them, in his relations to mankind and to the universe. Things must not always be looked at with a pocket lens. To understand things, a man must view them with his own eyes and try to grasp them in their entirety. After he has gained the large vision, he can pick out the details, but, if he begins with the minute features, he will never get the large vision.

The large view is the natural one to the boy. He sees a clock and at once is interested to know what it is for and what it does. Then comes the question how it is constructed and what makes the wheels go round. Thus far he is greatly interested, but rarely is the boy found who cares two raps whether the wheels are made of brass or iron. He does not naturally go farther than his unaided senses carry him. The use of the microscope is an acquired taste, like the taste for olives. It would almost seem, however, that modern science teaching had entirely lost sight of this natural order. We rarely begin with the study of the large features of the world about us. Botany, physics and chemistry in some form or other are presented to nearly every youth who takes our scientific courses. He is taught to use the microscope, the scale and the vernier, and to reason about the atomic arrangement in the molecule but rarely to consider what the river that runs in the valley is doing, or why the rock quarries are generally on the hillsides. To him New York is the greatest city in America simply because it happened to be, and it might as well have been located on the New Jersey coast if some Dutchmen years ago had not chanced to land near Castle Garden instead of Long Branch. He thinks that Massachusetts does more manufacturing than Texas simply because the Puritans "got an idea into their heads" that it was easier to make a living by running machinery than by herding cattle. He reads that a democratic form of government was developed in Greece, and has an idea that if the Greeks had lived on the plains of Babylon, they would have developed a similar democracy there. It was simply a matter of blood. Flannel suits and felt hats are just as good clothing for Cuba as for New York, and the people down there don't wear them simply because they have acquired the habit of wearing something else. In other words, he has not learned that man to a great extent is a creature of his environment. As he has not been taught and has never been encouraged to find out what effects different features of the earth exert on man, he takes little interest in investigating the origin of these features. Here we are, dependent on old mother earth almost entirely, and yet many of us feel very little desire to acquaint ourselves with her characteristics.

Earth study should deal with the earth and its relation to man. It may be the study of political geography — how the different divisions of men arrange themselves on the globe; it may be mathematical geography — how man measures the earth and determines his position on it; or it may be physical geography — how the different motions, forms and activities of the earth affect man. Whichever we study, we are only endeavoring to appreciate one of the characteristics of our old mother, on whose bosom we rest and on whose bounty we subsist. This desire to know about the earth is one of the earliest instincts of man. A thousand years before the Christian era the Phenicians were sending out exploring expeditions to unknown regions. The same spirit is dominant in us today. What have men not suffered in arctic and Afric expeditions simply to find out something new about the earth! This desire is most reasonable, because geography is the generalized type from which the other sciences are descended. There are few subjects except the purely mathematical or speculative which do not have one corner at least of their structure resting on geography. It is necessary in geology, zoology, and botany constantly to keep the geographic relation prominent. To understand any of these subjects, geography must be considered in at least more than one of its broad aspects. What does the zoologist or botanist really know of his specimen unless he has learned both the geographic position and condition of its habitat? He must know where it was found, whether on mountain, plain or valley. "All specimens to be valuable must have their location given." Of what value, however, can location be without some knowledge of the influence of geographic forms?

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History, economics and sociology are as dependent on this subject as the sciences already mentioned. Who would dare to discuss the history, economic or social condition of a people without first making a careful study of their geographic relations; not simply their position on the surface of the earth but their geographic surroundings? Could the Swiss republic have existed without the Alps? Would the barbarians ever have conquered Rome but for St Gotthard's pass? Could England have existed if the plain joining Dover and Calais had not been breached by the ocean? What after all dispossessed Spain of her possessions? American aggression or the stagnation of isolation caused by the barrier of the Pyrennees on the north and the natural byway of the straits of Gibraltar on the south? Would it be possible for the family feuds of the Tennessee mountains to exist in New York? Is not the somewhat peculiar difficulty of the study of the economic and sociologic conditions of our country largely due to the great diversity of its geographic conditions? Would it be possible for these complexities to occur in Holland or on the Russian plains? In none of these cases can a just appreciation of the fundamental conditions be obtained without a rather exhaustive study of the geographic element. This study must embrace the large topographic features, the climate, the winds, the soil, the condition of erosion, the general arrangement of the rock layers, the water supply, and many other things for the appreciation of which a geographic preparation is necessary. Yet how few men dealing with these subjects or interested in them have ever given any serious attention to the earth itself! Why even Job, who, as far as I know, made no pretense of having a scientific education, knew a good deal more about the activities of the earth than many of us. In Job 14: 18–19 we read:

> And surely the mountain falling cometh to naught,
> And the rock is removed out of its place;
> The waters wear the stones;
> The overflowings thereof wash away the dust of the earth;
> And thou destroyest the hope of man.

The great child of the east had learned to appreciate the dependence of man on the hand of the Almighty as shown in the action of the agencies of the land and had carefully considered the ways in which these agencies exhibit themselves.

The need on the part of educated men of a systematic knowledge of geography has made itself specially felt in the latter part of this century, and has been most extensively met in Switzerland, the country which above all others owes existence and prosperity to its striking geographic forms. There three of the universities allow geography to be taken as the major for the degree of doctor of philosophy. In the common schools geography is one of the principal subjects and a large amount of field work is done. Germany, though behind Switzerland, is doing considerable in this line, and England is waking up to the necessity of this kind of work.

Of all the countries of the earth, however, our own should be the country in which geography should specially flourish. No country exhibits so many striking and diversified phenomena as ours. There is hardly a geographic form or a geographic activity which is not represented somewhere within or near the borders of our own land. Then, too, our country is so young and artificial changes have accomplished so little, that the geographic features exert here a domination over population and life which they do not exert in some of the older countries. The extent of our country, also, demands of us, if we would appreciate its different conditions, a power of geographic generalization which citizens of other countries do not need. The man who can picture to himself the geographic conditions which surround his fellow countrymen in Alabama or Texas or Oregon will have less sectional prejudice and will become a broader-minded and more valuable citizen. He will perceive that the manner of life is different in different regions and that what might be thought for the good of New England may not be for the good of Kansas. How can he acquire this appreciation, however, unless he visit the different sections or by the systematic study of land forms and conditions have his imagination properly cultivated? As many of us can not travel extensively we need to acquire the foundation for geographic imagination. Then, too, the territorial possessions of Americans are increasing, and they must needs appreciate conditions more diversified than those confronting them even in their broad home land. If we as a nation are to deal justly and advantageously with Puerto Rico and the Philippines, we must be taught in every possible way to understand the conditions there. National justice demands that we shall inform ourselves and see that the coming generation is taught to comprehend these conditions. Pres. Eliot, than whom there is no keener student of education, in a recent address at Philadelphia, particularly emphasized our peculiar need of geographic study.

Leaving out of consideration our duty as citizens, we Americans should study geography for our pleasure. We are a nation of travelers. Last summer, while sitting at the table of a hotel in Geneva, I heard an English lady remark to a friend: "You can't go anywhere but what you meet these Americans. Today we ran across a party of 30 school teachers. I don't see how they get the money to travel." This remark shows that even we poor school teachers are travelers and, if we can travel, who can not? Every American child expects to travel and to see everything that it is possible to see. He believes that, after his father and George Washington, Robinson Crusoe was the greatest man that ever lived and that Gulliver came next. When the American gets too old to travel for pleasure, he is ready to take his last journey. Now what can give a person greater pleasure in traveling than to understand how the country over which he passes came to be what it is and to appreciate the natural forces he sees about him? How much it adds to the pleasure of a trip through Switzerland to know how the glaciers are formed, what they are doing, and what they have done! A sail down the Rhine is rendered more enjoyable by understanding how its beautiful gorge was cut. The grand view from the Drachenfels is not made less attractive by the knowledge that the seven mountains which rise above the old pene-plain are simply old volcanic remnants. One really appreciates the fine grassy meadows of England better if one knows that this firm, springy sod is produced by prevailing westerlies and the gulf stream. All the knowledge one has of the why adds to one's pleasure.

It is generally conceded that the mountains, valleys and plains have been formed by agencies which are at work at the present time. Though all these agencies do not operate at any one place, yet to the observing eye some of them appear everywhere. No others have had so much to do with the characteristic features of the surface of our planet as erosion and deposition. By their action came our mountain peaks, our valleys, our hills and in fact almost all those features particularly related to man's welfare. The shower on the hillside, the little valley, the brook, the pond show their processes and results as characteristically, though, perhaps, not as strikingly, as the huge mountains, the vast rivers and the ocean. And not only this, but the industries engendered by these smaller features are an epitome of those made possible by the grander formations. With the eyes rightly trained and the imagination properly cultivated, we can from our own surroundings accurately picture the conditions over a large part of the earth's surface. The map and the photograph of course, greatly aid in giving the right local coloring to the picture, but without a foundation of systematic geographic knowledge the right perspective is never obtained.

The study of the home locality is one of the most important as well as pleasing features of a rightly conducted course in geography. If there is one thing we restless, nervous Americans need to cool our heads and help us see things in their real proportions, it is to get out into the open and look at God and nature from the vantage ground of the hills; to try to picture to ourselves what the quiet, unobtrusive forces of nature about us are doing, and to see, beyond the bustle and worry of our lives, the serenity and unvarying persistency of nature's forces. For our highest development it is not as essential to hunt for the flower, the fossil and the mineral as to strive to know the mountains, the rivers and the valleys. The former resemble Donatello's beautiful bronzes; the latter, Michel Angelo's noble statues of David and Moses. The lives of many of us are so petty that we need the uplifting of a personal acquaintance with the grand aspects of nature.

For many, field work in geography is easier than in geology or even botany. No hammer, no bag, no can, is needed. The notebook and map are the only essentials. No severe manual labor is required and almost all the tramping is along the roads. These are exceedingly important features when classes of girls are to be conducted.

Another feature of the systematic study of geography which peculiarly adapts it to a place in our schools is the quality of its laboratory work. Conditions of dress and manual dexterity render laboratory work in physics and chemistry ill suited to many girls; and yet on these very accounts the need of doing something with the eye, the brain and the hand is perhaps greater for them than for boys. Zoologic laboratory work also is often distasteful, and thus it happens that in many of our schools there is no laboratory really adapted to the needs of the girls. Since geographic laboratory work need not be quantitative and mathematical, but must be appreciative and reproductively imaginative, it does not call for those operations which are usually distasteful to girls but for those which are usually agreeable. It thus brings about the needed correlation of mind and hand without any unpleasant features. It might also be urged that girls specially should make a systematic study of geography because about all the geography teaching in the lower schools is done by women. If the work there is ever to be brought to a high standard of excellence it must be by a careful training of the women teachers.

Probably the result of laboratory work which in the end is the most valuable to the pupil is the self-reliance acquired by doing the thing that he sets himself to do. The thing done should be valuable in itself, for life is too short for time to be squandered in valueless employment; but long after the specific results of the laboratory work may have been forgotten, the good effects of having actually done something will remain. The cram and jam of modern education, necessitating as it does everlasting explanation and illustration on the part of the teacher, has taken nearly all the relish of personal mastery out of student life. Laboratory work properly conducted relieves to some extent this most deplorable defect. In order, however, to allow the fullest benefit in this direction, there must be the least possible intrusion of the complexity of apparatus between the doer and the thing he is asked to do. In other words, the pupil must see clearly that he, and he alone, is responsible for the work accomplished. He, not the apparatus, not gravity, not chemical affinity, not the protoplasm, must produce the results. Of course he can not expect that the results will be really original, but he ought to invent the method for himself. He should not be dependent for the how on the explanation of the teacher. As far as my own experience in laboratory instruction goes — and it embraces chemistry, physics and zoology — no subject more fully fulfils these requirements than geography. Here, as in Squeers's famous school, the pupil learns what a thing is and then he goes and does it.

There seems to be one focus toward which all geographic teaching must tend: the relation of the earth to man. The humanistic side must ever be kept prominent. It is not the earth alone nor man alone that we should study, but the earth and man. The earth's motions, its forms, its activities should be studied, not as ends in themselves but in their relation to man. Winds, ocean, currents, mountains and rivers are to be viewed by their effect on his industries, his powers of communication and transportation. The way in which he determines his position on the earth, the way he represents its surface by maps and charts should be considered. The habits and customs of men in different parts of the earth, since they are to a great extent the result of physical environment, should be noted. The casual idea should be brought in wherever possible and the word why should always stare the pupil in the face. Whether taught in the lower grades or in college, geography should be a generalizing subject, the extent of generalization being dependent on the grade. It would perhaps seem best not to carry this aspect as far as the English do in the subject they call physiography, but it is necessary that all the great aspects of the earth and their relation to man be here considered. There is great need of a broad subject of this kind which can to some extent bind together the separate units of earth and man knowledge and show them in their right relation to human development, the great end for which all knowledge should be desired. Unless these great unifying subjects are made from the start an important factor in educational systems, the education of the future will simply be specialization gone mad, and we shall look in vain for the educated man who, like Moses, will have neither his eyes dim nor his natural force abated.

**Prof. R. H. Cornish** — What science subjects shall be included in the secondary school program? What amount of time shall be given to each? In what order shall they be presented?

These questions are inviting discussion not only here but throughout the country, in gatherings like this. Out of such discussion, it is to be hoped that some agreement of value to science teachers will soon emerge. If science teachers can reach an agreement, their claims will come before principals and others engaged in considering courses of study with much greater force than at present. I wish to make the strongest possible plea for the retention of one at least of the earth sciences wherever it now is and its inclusion wherever it is not. In my judgment, for the majority of schools the country over, specially in large cities, physiography is the best to include. In this state, the classic ground of the geologist, where sections of sedimentary rocks are so easily found, geology has undoubtedly equal claim. Local conditions might determine which of these two should be taught if both can not find a place. What I shall say applies with equal force to geology and physiography, though I have had the latter subject chiefly in mind while preparing this paper. By physiography I mean something different from the old term, physical geography, and something different from what is signified by the term, physiography, as used in Great Britain. There physiography means an introduction to all sciences and embraces the elements, at least of botany, physics, chemistry, geology, mineralogy and astronomy.

In this country much of this work is included in what we call nature study. It is desirable that the acquisition of this elementary knowledge shall be distributed through all the grades below the high school. Physiography ought to include what physical geography comprises but with the emphasis placed on the study of the land, the processes of weathering and erosion, and the cycle of development which various land forms assume in different stages of their history. It ought to include a study of the earth as a planet, elementary astronomy, of the air, elementary meteorology, of the ocean, and of the land, the latter being the most important topic and demanding the fullest treatment. The earth should be looked at from the organic point of view; that is to say, the earth has a history, it is constantly changing through the operation of internal and external forces; we live on it at a particular stage in its history, and from its present and past conditions we can make certain reasonable prophecies as to its future. Now physiography, treated thus and having the physical environment of man as its chief object of study, has imperious claims on our attention.

In the first place, it supplies the student with most important and valuable information. If we consider the temperature, rainfall, winds and other facts included in the terms, weather and climate, the tides with their complicated phenomena, the kinds of soil, the rock structure and constituents which determine both soil and scenery, the distribution of rainfall as over-water and under-water — all of which in one way or another affect our lives — we must admit that this knowledge is practically useful and intellectually valuable.

In the next place, it is second to no other science in disciplinary value and thought-kindling power. Physiography affords a large supply of problems on which the ingenuity and reasoning faculties of the student can be exercised. The subjects presented by teacher and text and in the laboratory and field call for constant use of the reasoning faculties as well as the memory and observation. Many of the facts presented in a systematic course must come to the student through the textbook or lecture. The earthquake, volcano, glacier and lofty mountain can not ordinarily be studied at first hand. Yet fixtures, charts, maps and lantern slides can make these subjects real and instructive.

In one respect physiography, or high school geography, as I would like to call it, is in my opinion superior to any other science, and that is its ability to call forth and develop the *constructive imagination*. Many problems can be given, or will inevitably present themselves, which call for the use of the imaginative faculty in a high degree. Some of these problems are astronomic, some meteorologic, some geologic.

For example, having presented the facts of the sun's apparent changes in position at rising, at noon and at setting throughout the year as observed in our own latitude, we ask this question: what are the phenomena seen throughout the year with reference to the sun's position at rising, at noon and at setting by a dweller at the equator, and by a dweller at the arctic circle? or this: what are the facts observed by an imaginary dweller at the north pole with reference to the sun's appearance and disappearance? or: what effect on climate would ensue if the axis of the earth were inclined 45° to the plane of its orbit, or were perpendicular to the plane of its orbit, or were in the plane of its orbit? or this: what is the front of a moving trolley car, of a baseball in motion, of the earth? and, when are we in front? The answers to the questions are broadening and enlarging to the mental horizon. The successive stages in the development of any land form, as for example a river valley, are instructive. To carry the history of a river and its valley through to its conclusion, with the various incidents that may occur in its career, on account of varying rock structure and position, of elevation and depression, calls for imagination as well as reasoning and observation.

Now as to laboratory work. We all agree that the laboratory forms an indispensable part of our teaching equipment. There the student makes his knowledge real, he discovers within limited range facts new to him, or verifies laws discovered by others. Whether the laboratory should be the central object in the method of instruction, I will not now discuss. That it is an invaluable aid all admit. Can it be used to supplement and aid the work in physiography as in other sciences? I believe it can. I shall include a certain amount of field work under the term, laboratory work, though at present field work seems for us at the Girls high school impracticable. There is a slowly growing literature relating to the subject of laboratory work in this department. Prof. Snyder has recently published in the *Journal of school geography* for December a list of 50 exercises which he has carried out at Worcester. About two years ago I described what I had been trying to do in the same line at the Morgan park academy. These exercises included the keeping of records of rainfall, temperature and barometer for a month; plotting curves to show graphically these same facts; finding the dewpoint and thus the relative humidity from the tables; constructing a map of isotherms, of isobars and of rainfall from facts given in the daily papers and combining these facts in a weather map; plotting the profile of a river from source to outlet from a topographic map, thus discovering its torrential and flood plain portion; plotting cross section of St. Lawrence river at Thousand Islands, from a lake survey chart; of profiles of various features found on a coast survey chart; of profiles of different features found on topographic maps.

The study of various maps as means of representation of the earth surface and the method of construction used in making the map formed an important part of this work. Among the maps so studied were the Washington weather map, a coast survey map, a lake survey map, maps of the Mississippi river commission, a pilot chart of the north Atlantic, a topographic map. After the topographic map as a means of expression is understood, it can be used to illustrate the various land forms met with in the systematic course. About six weeks of this laboratory work was devoted to a study of common minerals and rocks. Incidentally I think the map study referred to developed an appreciation of fine maps. The construction of a topographic map of a small river valley from material gathered by a survey of this on the spot was perhaps the most interesting and difficult piece of work attempted. The results were quite gratifying. All this work requires the most careful planning on the part of the teacher to give definiteness and proper direction. Copying diagrams and looking at pictures or maps, however necessary at times, is not laboratory work in any proper sense, though it may form a part of it. The aim of the teacher in this exercise should be to put before the student some definite problem or question, however simple, that will enlist some of his faculties in addition to his eyesight.

Besides this laboratory work, which consists in solving certain definite problems from material put into the hands of the student, I devoted a number of laboratory periods to library exercises, in which I tried by the topical plan and assigned readings to familiarize the pupils with some of the literature of the subject. Among subjects that have been so discussed are the following:

1 The structure, method of formation, rate of movement and erosive action of existing glaciers.

2 The evidences for and extent of past glaciation.

In conclusion, I would urge the giving to physiography of a place in the secondary school curriculum on account of its informational value, its disciplinary power and its fitness to develop the constructive imagination. It ought to have a full year's time and to be accompanied by carefully prepared laboratory work and wherever possible by field exercises. These exercises will interest and instruct the pupil. They should be selected to throw light on the systematic study as it is presented in the textbook. The latter will, I suppose, be the central object in the method of presentation for a long time to come.

**Prin. T. B. Lovell** — There seems to be some hesitation in opening the discussion. I desire to speak representing those connected with high school work. I was intensely interested in the papers of the first and second speakers and in their opinion that there should be an intensive study of geography in certain lines in the lower schools of our state. Col. Parker, of Chicago, in a course of lectures, afterward published in a book, gives as his opinion that geography is the foundation, and the whole system of study is based on geography, with psychology at the head. Those who have read the work know that he defines geography as a study of the surface conditions. That is in accord with the first paper read. After the study of surface conditions comes the study of conditions under the surface, geology. Then the study of the conditions above the earth, with reference to air, clouds, storms, etc.; then the changes on the earth, the animal kingdom and its conditions as presented by the first speaker. Thus he builds up the whole course of study on geography. The geologic conditions lead us to the study of animals, with their habitats, and then to the study of the highest forms of the animal kingdom — men, and their physical condition, and development of mind, introducing the principles of psychology. I am inclined to think that not all the teachers in the state of New York are teaching geography with this idea in view. Some simply teach that this river is located here and is so many miles in length, and that city is there and is important; but why the river is here and why the city there is seldom mentioned.

In the study of zoology we can recall the surface conditions, why this animal or that is in this part of the world rather than in another. In astronomy we recall the conditions of our earth, that it is a part of a certain astronomical system, and this should be studied, it seems to me, from the conditions of the earth first. Geology, we know, must be studied as to earth conditions. I think the teachers in high schools would know more with regard to the science spoken of under the term " earth science " if there were a faithful presentation of the conditions which ought to be considered in the study of zoology. In the good book Job says, "And He hangeth the earth upon nothing." Is there anything truer than that? The same book says with reference to another condition, "Having eyes they see not, and having ears they hear not." Is not that the state of those who have studied geography under the old conditions, simply studying about facts instead of learning to see on the earth the conditions relating to geographic science, and learning from the rivers, the mountains and the fields that which will contribute to an uplifting of the heart?

## COLLEGE ENTRANCE REQUIREMENTS IN SCIENCE

BY DEAN W. H. CRAWSHAW, COLGATE UNIVERSITY

I should like to make it as clear at the beginning of this paper as it is sure to be at the close that I do not approach the discussion of this subject as an expert in science. My point of view is simply that of a college officer who is an interested observer of educational progress in all lines and who desires to preserve an open mind toward the claims and qualifications of all educational subjects. What else should be the desire and purpose of a true teacher? Education has nothing to gain from narrowness and intolerance; it has everything to gain from a free and hearty recognition of educational values wherever found. If, then, it is possible to say anything useful from such a position as mine, I shall be heartily glad. If not, the fault is with your officers, for they were frankly warned of my plentiful lack of qualifications.

The educational value of scientific study is something which we may take for granted, as beyond all reasonable doubt. It is too late in the day for that to be an open question; and certainly it would be carrying coals to Newcastle to argue it here. Science, I take it, tends first of all to cultivate a familiar acquaintance with the phenomena of nature and to develop the power of accurate observation. The mind is also trained to sympathy with nature and to close and sure reasoning on the phenomena which it has observed. Still more important is the cultivation of the scientific temper and attitude of mind. Of even greater importance yet is the fact that science has taught us all the benefit of studying the thing itself rather than studying about the thing, a lesson as important to literature or art as to any branch of scientific study. If I add that science tends to cultivate a love of truth for the truth's sake, I may not yet have said all, but I have at least indicated its transcendent worth.

We have had much discussion of the educational equivalence of all great branches of study. The true claim of science does not lie in that direction. Different studies may possibly be equivalent as to degree of educational discipline and value, but they are certainly not comparable in kind. Each branch of study has its own peculiar aptitudes and results. Science furnishes a characteristic discipline which can not be furnished by anything else; and this discipline is a necessary part of a symmetric education. From this point of view, science may fairly challenge a place beside the more traditional subjects of study.

I do not understand that the position of science in the secondary school needs to be proved or defended. It is there; there to stay and to grow. It has not yet a large enough place, but it may be trusted to win a fuller recognition by its inherent worth and by the agressiveness of its champions. The obstacles do not seem to me very formidable; for justice and common sense are on the side of fair and liberal treatment. Science will ultimately get all that it shows itself to deserve, and its advocates need have no fears to the contrary. Unless I am seriously mistaken, the quality of science teaching has within recent years vastly improved and is still improving. With this improvement has come increased recognition, and this is the only sure road to the attainment of its proper heritage.

There does not appear to be, so far as I can discover, any consensus of opinion as to just what science should claim for itself in the field of secondary education. I am no advocate of a dead uniformity; but, if science is to attain its ends, there must be a reasonable agreement as to its desires, its methods and its aims. How is such a degree of uniformity to be attained? There seems to me to be only one answer. Teachers of science, by consultation, by discussion, by experiment, must arrive at some sort of common understanding as to a practicable mode of procedure, and it is doubtless through such associations as this that an understanding may best be reached.

I have been asked to touch on some of the practical questions here involved. I do so with much hesitation and timidity; for this is burning ground, and I do not willingly rush in where angels fear to tread. The first important question is what sciences should be taught? I will give at least one evidence of discretion by declining to touch that question at all and saying that it is purely a question for the scientific expert. Somewhat the same might be said of the order of study, though I take it that that is less important. Perhaps you will allow me to hide myself behind the burly figure of the great Dr Johnson, who once said to Boswell in answer to a similar question: "Sir, it is no matter what you teach them first, any more than what leg you shall put into your breeches first. . . Sir, while you are considering which of two things you should teach your child first, another boy has learnt them both." A more important question is how many sciences should be taught? To this, I should answer, one, if that is all that a school can teach well. In general, teach as many sciences as you can teach well, and no more. I see no objection to the proper teaching of any number of sciences, allowing students a judicious selection among them. Allied with this is the question whether several sciences should be studied for one year each rather than one science for four years. As George Eliot makes the landlord in *Silas Marner* say, "There's two opinions; and if mine was asked, I should say they're both right." I confess to a feeling that one science thoroughly and comprehensively taught will probably give a student the best grasp of scientific method and the greatest ability to shift for himself in other lines of scientific study. On the other hand, I can not ignore the value of the broad view and the opportunity to compare methods in different branches of science, nor can I forget that many science subjects are pressing eager and valid claims for recognition. With some hesitation, I will venture to suggest that a reasonably good course might be made by teaching for one year each, three typical subjects, each representing one of the three great divisions of science — the physical sciences, the earth sciences, and the life sciences, this to be followed by an advanced year in some one of these subjects. I will not undertake to defend this view, for certainly here discretion is the better part of valor. The important thing is that you who are competent to judge should come to a reasonable agreement on principles and a reasonable uniformity in practice.

What has thus far been said is not without its bearing on the specific subject before us, "College entrance requirements in science." If science has a true educational value, if it is a necessary part of a symmetric training, if it has a legitimate place in the curriculum of the secondary school, if it is possible for science teachers to agree on a practical and effective plan of study, then it comes pretty near to being a matter of course that the college should and will give recognition to what the school has done.

Something else needs to be said about matters of practical detail; but the principle of recognition depends on these considerations.

The college is under obligation to recognize so far as practicable all proper work of the lower schools. It is under special obligation not to ignore or discourage so important, so vast, so essential a subject as science. The college, however, has also a duty to itself; and in these days, when so much has been done to undermine its foundations, the college must guard its own position. This is all the more important because the claims of science are so great and so just. Once admitted to full recognition as a basis for college entrance, science is destined to affect the college profoundly; and our duty is to see that it receives recognition in such a way that its great influence will be turned in the right direction.

What, then, are some of the considerations which should affect college action? In the first place, as I have already implied, the quality of science teaching in the secondary schools. The college has a right to insist that the science recognized shall be genuine. How to make it so, is a question for you to decide; but I am sure you will be the first to declare that thoroughness and effectiveness may rightfully be demanded and should be carefully tested. I would venture to suggest also that science has cultural as well as disciplinary value, and that, for the purposes of a college as distinguished from a technical school, this value ought not to be ignored. At any rate, science should be taught with an effectiveness equal to that of other departments. Whether it has yet reached an equality with mathematics and the classics, you can judge better than I. All that I care to enforce is that secondary science teaching can not expect college recognition till it has first justified itself by its works. If it is already fit, let it declare that conviction with emphasis and demand its rights. If not, let it throw its whole energy into making itself fit. Perhaps some limitations are due to lack of proper recognition in school curriculums. That battle the science teachers must fight out with the school authorities. The college can best help them in fighting it by announcing its willingness to accept such science as is satisfactorily taught and by refusing with emphasis to accept any science that is not satisfactorily taught.

Again, the college ought to have something to say about the character of the science work to be accepted for entrance. I do not mean that the college should dictate the course of the secondary school. Far from it. One of the points proposed to me for this discussion was whether the college should prescribe certain portions of each branch required or should accept the secondary school course in it as a whole. If I had to answer that question one way or the other without qualification, I should say that the school must prescribe its own courses and the college may then say how much of them it will accept. The school can not have its courses prescribed by the college; but neither should the college have its entrance requirements determined by the school. Both are vitally concerned; and it is for the interests of both that they shall work in harmony. I do not see any way to attain this end except that the school shall seek the advice and approval of the college in prescribing its own courses, and that the college shall then present entrance requirements to correspond with the school work. In this way college needs will be met, and all the work of the school will receive recognition.

What is it, then, that the college ought to expect from the scientific teaching of the schools in addition to good quality and proper method? First, that school courses shall be well defined, so that the college may estimate the amount and kind of work done and know precisely what it is asked to accept. Secondly, that at least a full year's work shall be given in each branch of science treated. Thirdly, that the school courses shall be of such a character that advanced college work may be based on them. What we ought to seek here, as in all other departments, is to have a series of correlated courses in each branch of study, running from the school up into the college. This we have notably in mathematics and the classic languages; and it is at least possible to approximate it elsewhere. The college should seek so far as possible to give credit for all that the schools do; but it must have a basis for its own work and can be asked to recognize only what affords such a basis. The schools, on the other hand, should seek, not only to make their work profitable in itself, but to make it also a step to something higher. Doing so, they will serve their own interests and those of their pupils as well as the interests of the college. Is it not a fair question whether this state of things has yet been reached? In some cases, at least, students presenting science subjects for college admission begin their subjects in college precisely where classical students begin who presented no science for entrance. What is more, the classical students are in the main quite equal to the others in scientific work. With due submission to your better judgment, this seems to me like serious educational waste. I do not feel any clear conviction as to where the trouble lies; but I should like to raise the question whether this is a sufficiently close correlation between the scientific work of the school and that of the college. May not preparatory science teaching be excellent in quality without affording much basis for advanced work of college grade?

Assuming that this correlation should be brought about and that scientific preparation was otherwise satisfactory, there ought to be no material obstacle to recognition. The question of practical method, however, would still remain. The solution must come, I think, through a system of elective college entrance requirements. This we already have in part through the choice which is offered among several different kinds of college courses, with their correspondingly different entrance subjects. The scope of this election must probably be considerably enlarged, in ways already pointed out by some of our leading institutions. Not only must we allow choice between various groups of entrance requirements, but we must allow choice within the groups themselves. Units of science must be accepted in place of certain other subjects; and choice must be allowed between different sciences. How far this freedom of choice must ultimately go, it would perhaps be impossible now to say. It would seem to be sufficient at present to suggest that we should have certain large groups of related subjects; that there should be a certain minimum requirement from each group, with freedom of choice as to particular branches within the group; and that the maximum requirements should be made up by free choice from any of the groups. The question would naturally arise whether any subject should be absolutely required. I should say, no, unless the subject can be shown to form a distinct division by itself. This might be argued in the case of mathematics, whose characteristic discipline and knowledge probably can not be supplied by any other study. If this be true, mathematics would be coordinate with science or languages or history rather than with chemistry or Greek or the history of England. A similar claim might be made for the study of English; not because English has any special claim as English, be it understood, but because in our case it is the native language and because the native language must always sustain a unique relation to education. Such a group system as is here indicated would give science a fair place beside other forms of educational discipline, while at the same time it would allow schools and students to choose among a considerable variety of sciences. Various subjects would then stand on an equal footing of competition. This is all that science should ask and, I believe, all that it does ask. It is no more than other subjects should be willing to concede.

There is another question, not quite within the range of my subject, but so closely related that I am tempted to touch on it. When a student has done advanced work in any subject beyond the college entrance requirement, should the college grant advanced credit? I shall not argue this question, but simply express my present conviction. I believe that the college should aim to recognize all good work wherever done; but I also believe that the college should demand work of college grade for college equivalents, as it demands work of secondary grade for college entrance. To do otherwise, would be to abdicate its proper office in favor of the secondary school. This seems to me a perfectly fair principle. It would involve accepting for advanced standing only so much of the work of the secondary school as could be shown to be really equivalent to similar work done in its own classrooms. I think that the college might properly refuse to accept school credentials for advanced standing and insist that such work presented for such a purpose should undergo the tests of college examination. Of course, if it were thoroughly satisfied that the work of a given school was entirely adequate, the credentials of that school might properly be accepted; but the presumption would be the other way, and in general, credentials for advanced standing should be accepted only from another college.

The general attitude of this paper is that students should be encouraged to come to college with a well rounded preparation in all the great departments of human learning that are within the range of their comprehension, and that to science should be accorded a fair place beside other subjects of study. It is possible for the college to afford to science much inspiration and encouragement; but full recognition of its just claims must largely await the action of the secondary schools. When teachers of science, by the character and quality of their work, have made it entirely clear that they deserve college recognition, they will get it, they will be in a position to demand it. Perhaps this time has already come. I sincerely hope so. If it has not, I trust that the day of success is not far distant.

**Prof. A. D. Morrill** — I am sure that all have enjoyed the paper to which we have just listened. It contains so many just observations that there is no need of referring to them. There are many directions which we might pursue in examining this subject of college entrance requirements in science. It seems to me that we are going along about the same line with the sciences that the modern language teachers have already followed with their subject.

It is hardly necessary to remind you that not long ago no one went to college unless he was preparing for a professional school, with a view to the ministry, law or medicine, and so was willing to take the examinations laid down in Latin, Greek and mathematics. After a time the technical schools were opened and the young men who wished to prepare themselves for the engineering courses found that the entrance requirements for these courses embraced a considerably larger proportion of mathematics and very little language. It was not long before these schools discovered that French and German were absolutely necessary, and these subjects were required. It was found that there was too little time to complete the work in chemistry and physics during the college course, and so the elements of these subjects were added to the entrance requirements. It was not long before some young men wished to attend the classical colleges and have the training in literature and the arts that was given there. They did not wish to take the technical course and they did not wish to take the full amount of language. Then came up the question, what could be substituted, what could be omitted? Greek was the subject that seemed to be fated in that particular, and the question was, what could be substituted for a portion of the Greek? Modern languages presented themselves and have been accepted in a large proportion of the colleges of the country; so that a person in place of Greek may take French or German or both. At first the requirements were not equivalent. This has been so adjusted that in the best institutions there is no question that the requirements are equivalent; a person who omits Greek must have at least the equivalent in time and training in French and German. Some find it quite difficult to do much with languages, while able to do excellent work in mathematics and in science. The colleges have been changing their requirements to some degree; and now one of the latest arrangements, one that is to go into effect next fall, is that certain definite subjects in language, history and mathematics must be taken, and then the rest can be elected, with a certain proportion from the different sciences. The sciences are put on the basis of a year's work of five hours a week, with laboratory work and with notebooks presented properly certified.

But the one thing that we want specially to bring into this brief historical outline is this, that the tendency has been to make the requirements in the various groups of subjects equal. It is not very long ago that they were unequal, but in many cases they have been made equal. It is not intended that the science work shall be of an inferior grade, shall be done in a less careful manner, with less satisfactory teachers and in a way to give less training, or that it shall permit a duplication in college of work already done. The intention is illustrated in the modern language work. Those who are familiar with it know that if a young man or young woman presents French for a year's work, he must be placed in the advanced classes; that is that the men who enter as freshmen are required to do the work with the juniors in classics, which gives them a pretty severe training. They must keep up with the others or be dropped from the class. In the larger colleges it is possible to put men who come in in that way together, but it is fully understood that they do not get any easier work, but that their work is just as severe as that called for from men in the so-called classical department.

Science will get full recognition in all institutions as it has already in the larger institutions, where it stands on a full equality. But, remember, there is one point to be emphasized, that is that it is mainly substituted for advanced mathematics or Greek. The next thing, after introducing it in that way as an elective is the question with regard to the requirement of science as a condition of college entrance from all, classical students and others. Some institutions do this for at least one science. But in the catalogues some simply say that they call for either chemistry or physics or biology, without any very definite statements of the exact amount required. I notice also that the statements of the larger colleges and universities in regard to what they accept are very minute and that they will accept only that. I know that a great many colleges have physical geography as one of the requirements for all students, but evidently this is the old idea of physical geography, hodgepodge of all the sciences learned from a book. In a few of these institutions, that have had the most experience, physical geography is one of the possibilities. It is a good subject. It seems to me very important that, if any subject is to be required of all students, it should be one that calls for careful training in observational work, real scientific work. I do not care what it is, but it does seem that some subject calling for at least five hours a week, with observational work, laboratory work and notebooks, should be a requirement for all. One reason why that should be the case, is this: elective courses in colleges are now being arranged in such a way that men can enter college with no preparation in science and the amount of science that they are obliged to take in college is so ridiculously small in some cases that it is hardly worth mentioning. In some colleges they are required to take only a brief lecture course in physics; in others a brief lecture course in physics and one in chemistry. But the tendency seems to be toward minimizing the amount of mathematics and the amount of science required in the college course. The men can elect almost anything, but they can reduce the mathematics to a small amount and the science to almost nothing. If it continue in that direction, it will not be long before it will be possible to go through college and know absolutely nothing, even by lectures, of any science. It is at present the case that a person can go through college and have absolutely no knowledge of any *observational science*, and a very heavy percentage do that. That is one of the important reasons why some science should be required. No institution will dare long to refuse to accept properly accredited science work as filling a part of the college entrance conditions.

**Edith M. Brace** — There ought to be unity of plan, with common interests and aims, throughout the educational system, to the end that the different parts may be harmoniously related. The primary school leads directly to the secondary school, the secondary school ought to lead directly to the college; and if students could be made to feel that a close relation exists, and the college is not something separate and apart by itself, there would be a larger registration for the freshman class.

There is a general uniformity in the work leading up to the secondary schools, and a similar uniformity is even more desirable in the work leading up to college courses; for, while elementary work is usually local and the primary and secondary schools of the same town can easily cooperate, in making the change from secondary schools to the college there is great latitude in the choice of institutions, and confusion and loss of time result unless students from the different places have followed the same general plan of study and are prepared to go on together in the same work. Exceptions to uniformity may be desirable in certain cases. If a school is located where there are special opportunities for certain lines of work, it would be a mistake to neglect those opportunities.

It has always been difficult to get any adequate recognition for work in science. Traditions have come down to us from early times, when learning belonged largely to monks and monasteries, where the sciences, little known, were not regarded as contributing to culture, and were supposed to be antagonistic to religion — a prejudice still potent. We do not easily get over the feeling that the essentials of culture lie along other lines, and the sciences are the frills of education that must be curtailed first whenever it is necessary to economize in time, expenditure, or teaching force. So it has come about that we have, for example, from two to four years' required work in Latin before college, with subsequent college courses in the same subject, as contrasted with a 20 weeks course in zoology before college, followed by one year of required work for the bachelor's degree in college.

This is too short a time to get a comprehensive idea of a science; and a science of life is too important not to receive full justice. It ought to be a corner stone in education. I have known students, far advanced in literary lines of work, who announced as a new discovery the interesting fact that the embryonic development of the individual epitomizes its ancestral history; yet that fundamental truth ought to be within the reach of even an elementary student. It is a matter of general interest to know that the nervous system in the lowest animals lies on the periphery, and that it sinks in, becoming better protected and more localized, as we go higher up in the scale, but is always on the surface in the early developmental stages of every individual; or to know that the ear served primarily as an organ of equilibration rather than for sound perception; that the organ for perception of light is not always a complicated eye, but may be a single cell, or, possibly, even a pigment spot; or to know of the mysterious effect of light from different parts of the spectrum in accelerating or stopping or reversing the flow of protoplasm.

The present application of science to practical questions has brought it into prominence. The relations between bacteria and disease, between loss of mental or motor power and degeneration in portions of the nervous system, the economic relations between insects and crops, with the mode of their control, and many other questions are constantly before us. An understanding of such matters gives an idea of the possibilities of life, broadens the sympathies and helps one to live effectively.

The college exerts a strong influence over the secondary school through its entrance requirements. It is a matter of expediency, if nothing more, to give the same work to students who go to college and to those who do not. Entrance requirements should be placed high enough to assure a thorough understanding of the fundamental principles of science to those who do not go beyond the secondary schools. The study of animal activities is both interesting and profitable, but some attention should be paid to the evolution of structure and to comparative anatomy. There may be difficulties attending the use of the compound microscope in the secondary schools, but it opens a new world to the student and is the key to some of the most important problems of science. If it is not used here, it is quite possible that 99% of the students will never have an opportunity to become familiar with it. Time should be given to allow the student to study the subject thoroughly. Instead of cutting out things that are really essential in order to gain time, is it utopian to attempt some adjustment of matters that will give the new sciences a fair chance with the older subjects? The mental training, the cultivation of powers of observation and of logical thought in correlating the facts observed and in reasoning out one's own conclusions, together with the importance of the subject-matter, gives any science a high value as an educating agent, one that keeps the student in touch with the interests and problems of the world. Aside from this, it furnishes him a practical equipment for winning a place in the world.

As the matter now stands, the question is not how to give the best course, but what to cut out and how to shorten, so that the subject can be given at all. The only thing to do is to readjust the time schedule and allow a proper amount of time for this work. The college, by insisting on a reasonable degree of preparations for entrance, can aid in raising the standard.

**Prof. S. H. Gage** — I think that we science teachers have just passed through a very enjoyable half hour. You who remember the organization of this association in 1896 will recall that we were not then standing where we are today. I take it that our friend, the dean of Colgate university, would not have given us that paper three years ago. That he has been able to give it to us today seems to me one of the great triumphs of our association. We of course have not been the only movers, but I think we have taken an honorable part, and I do think we ought to be happy this morning that such a paper could be given before this association. I think no more fair and full presentation could be given of the claims of science in the education of the modern man than that given to us by Dean Crawshaw. There was one point in his paper to which I would like to revert. It formed a part of the first address before the association, which I had the honor to give, and I touched it because, after talking with some college presidents, I got the same answer exactly that he has given us this morning. "When your work is good enough we will accept it." Now I said this on that occasion: "It is discouraging, almost prohibitive, for the college to say to the secondary school, 'When you reach a proper degree of excellence in your science work, the college will consider your appeal for recognition'." That is what was said at that time, and we say now that it is almost prohibitive. Why can not the colleges state clearly and explicity what the standard of excellence should be, and then in all fairness and justness say, "When your students reach the standard, we will accept their work on the same terms as other preparatory work"? No true friend of science would ask the college to admit students with a training in science inferior to that required in the older disciplines. But I do want to make this appeal: college men do not say, "When you lower teachers get good enough, then we will recognize you," but say to the teachers in the lower schools, "Do this kind of work and we will recognize it," and tell explicitly the kind of work that is wanted. As the teachers of mathematics and languages in the schools have been helped and guided by definite statements from the colleges of the requirements in those subjects, so science teachers would be guided and encouraged by similarly definite statements of the requirements in science for entrance to the higher institutions of learning.

**Prof. William Hallock** — I rise to second the idea that the requirements of the college should be specific. We have maintained for some time, whether it is so or not, that one reason why the classics have held their place in the secondary schools with so firm a hold is simply that they set a definite point to which the pupil was to be brought and had a definite aim always.

in view; and that, just as quickly as the college entrance course sets a definite aim in science, the secondary school curriculums will be adapted to it.

In the second place; it is, I think, superfluous to say that the colleges will recognize a science when it is properly taught. They do not tell the Latin teachers that they will accept Latin only when it is taught right. They say simply, "When your pupils pass our entrance requirements in Latin, we will admit them," and the two things are on exactly the same footing. It is simply putting off the evil day to say, "When you teach science right, then we will begin to talk to you." I am sorry to say that I know of institutions that take that point of view and oppose the study of the sciences in the secondary schools. Why? Simply because they think science is not well taught, and, instead of trying to help these schools teach it satisfactorily, they say, "No, you'd better leave it alone altogether; you'd better leave that to us."

**Prof. C. W. Hargitt** — I want to add my word of appreciation of what has been said and to add one other thought, that is that we are already aiming at this specific statement of requirements, in the work of the committee of nine and its subcommittees, some parts of which have already been adopted by this association. I would suggest, in the discussion here of the work in science in the secondary schools, what I suggested in the section room yesterday: we are not to lose sight in the midst of the appeals for additional science teaching in the secondary schools of the fact that some of this work will surely come up to the college authorities for recognition as a condition for entrance; and I want to repeat before the entire association this morning that, while we need not make the college requirements for admission in science the fundamental or primary guiding principle in the science work of the schools, yet we can not afford to lose sight of them, bearing in mind all the while that some of the students in the secondary schools will offer that work and ask for its recognition as a condition for entrance to college. Now, if we had a multitude of such college professors as the one who presented to us this admirable introductory paper this morning, perhaps we should not have much difficulty along this line. It is gratifying to know that we have made an impression on the colleges, and I should like to believe that there are such professors in more places than Colgate university. I will close by saying, not, may the shade of Dean Crawshaw never grow less, but may his species be greatly multiplied.

**Prof. A. T. Seymour** — There seems to be an impression that teachers of physics in secondary schools teach with the sole aim of preparing students for examinations of some kind. So far as examination questions are a test of ideal teaching, we would seem justified in preparing our students to pass them. Doubtless men of ripe experience are the best judges of what should be taught, and we ought to look to such men for our ideals. If college entrance requirements are low, what student will study to pass them? To a certain extent teachers of physics must get their cue from the colleges, but there are higher ideals than these.

I should be ashamed if my students could not pass the regents or the college examinations at the end of their course, though few will ever go to college. But since the mass of high school students will not seek a higher education, they should be taught without too much reference to examinations, and there should be greater emphasis on the things that will be useful in after life. Science teachers should not be handicapped in their efforts to teach such things.

There is a sign which argues well for a close union of all these interests, that is that the college men and the regents examiners take a lively interest in our work and are willing to meet with us at these annual gatherings to stimulate us and to listen to our side of the question.

As to my own method, I would say that the individual laboratory method finds the first place. Results obtained here are clinched by close questioning both during and after the exercise.

The student, not the subject, is ever kept in mind. At times the lecture method is adopted, though this differs much from a set discourse. Notes are taken by the student in the regular notebook, though these are afterward carefully distinguished from the student's own experiments. This notebook is the student's property and should contain as much useful matter as possible.

**Prof. E. N. Pattee** — It seems to me that any feeling of antagonism between the secondary school and the college is the worst thing we could have in this association. We should work together here. If the reports of the committee of nine on physics and on chemistry represent the best that the secondary schools can do, let the colleges accept them and base their work on them. The report on chemistry is a good report, and I am willing to take it and base my work on that preparation. Let us take these reports and outline as good courses as possible, as good work as the secondary schools can do; then let the colleges make that their basis and not adopt some other requirements, compelling the schools to try to do double work.

**Prof. W. D. Merrell** — The course should not be adapted to the needs of the few who will go to college. In talking to the many I may have made a mistake, but I have always told them that I should advise their taking such subjects as would enable them to go to college if they should subsequently make up their minds that they wanted to go. It is possible so to arrange a course in the secondary school that the pupil may think he has learned all about a subject and does not need to go to college to learn more. It is possible to make a course in the secondary school which will be of immediate value to the secondary school students, and at the same time will be of ultimate advantage to all. That leads to this question, What is the kind of work that the college wants done in the secondary school, and what the nature of the work which the college instructor can do when the student comes to him from the secondary school? Whatever the subject, biology or chemistry or physics, what training will enable the student to start in on a stronger course than he has taken in the secondary school? It is not always possible to build on the secondary school work in such a way as to make the first course in college an advanced course, but it can be made a stronger elementary course. We all admit that the secondary school course is perhaps based on the one condition that the student is to learn to observe facts, to arrange these facts and to draw definite conclusions from them. In other words it is a study in inductive reasoning. If, during the secondary school course, the student by the time he reaches the third year has lost his interest in the observation of facts, something has happened to that student that ought not to have happened, because the desire to answer the question *why* has been removed from his mind. I believe that every college instructor would like to have students come to him trained to know that scientific truths should be drawn first hand from the objects themselves — not from pictures of the objects or from books. What the instructor would like is the training that will lead a student, when he is told to discover how a slipper animal turns over, to bring the animal under the microscope and find out. We desire simply the understanding on the part of the student that he is to work from facts and not from any description of facts. Such work as that will be of value to the student who does not go to college, because it will give him the foundation and a proper appreciation of science, and enable him to acquire new facts and to correlate those with things previously learned. That is the way the knowledge of any science is built up.

**Dean W. H. Crawshaw** — As to differences of opinion arising from the difference between my point of view and yours, all that I can do is to throw myself on the mercy of the court. I began by confessing with perfect frankness that I did not approach the discussion of the subject as a scientific expert, and I recognize fully that you are the most competent judges. I should be willing to admit the assertion that the colleges could do very much for the secondary schools by setting a definite standard to which the schools might approach. Let me suggest, however, that science is not quite to be compared with the classics and mathematics in this matter. It is a new subject, and traditional standards have not yet had time to develop. Theoretically, all subjects should be on the same basis, but, in the nature of things, science can not stand with the other subjects till it has worked its way up to the practical recognition which these have attained. The attitude of the colleges is certainly a natural one, however much it is to be deprecated. I think that my own position on this point was in part misapprehended. I would not have the college stand off in cold isolation and say, "When you get ready to show what you can do, we will give you recognition." My thought was rather this — that you, in such an association as this, might take the initiative in saying just what secondary science teaching is prepared to do, and what it might reasonably expect in the way of college recognition. The college is not in so good a position to judge. When you are ready to say to the colleges, "We have certain just claims, and we make certain demands," then, I believe, your demands will be met. Not that the college should put itself in a repellent attitude, yielding only to pressure, but that you science teachers (and I distinctly stated, you will remember, that perhaps the time has already come) ought to say frankly whether your secondary school courses are yet ready to claim full recognition. If they are, then the thing for you to do is to say so with an emphasis that we can not mistake, and make your demands as strong as you can. I will say to you candidly that any doubts of mine about the present condition of science teaching have been chiefly due to reading scientific journals and the proceedings of just such associations as this. These publications lead me to suppose that you are not sure in your own minds as to just what you ought to demand in the way of college recognition. So long as this is so, you will find the question a hard one to get satisfactorily settled.

Another matter. It has been argued that you should teach, not for the sake of the college or a regents syllabus, but for the sake of the subject. I would assent to that, but I would go still farther. You will make a mistake in science teaching or in any other teaching if you teach for the sake of the college, for the sake of the regents, or even exclusively for the sake of the subject. Teach for the sake of the man. Take hold of your boy and your girl and give them all the advantage for manhood and womanhood that the subject you are teaching is capable of affording. That is your true aim in education. But, when that is done, when you have forgotten the college and the regents and have taught for these higher ends, should not your work afford some basis for higher study? Can you come up with something that furnishes no basis for college work and ask the colleges to give it recognition? Can you ask them to put it into their entrance requirements? I know of cases where students present for entrance to college a year of physics and a year of chemistry and a selection from certain other scientific subjects, being allowed to substitute this for an equivalent amount of Greek or Latin or modern languages. Then, when they come into the scientific classrooms, they begin precisely where the classical students begin who have offered no science for entrance. If that is not educational waste, then my powers of logic utterly fail. The college has a right to say that those men who present science for entrance shall be prepared to go on with advanced courses.

## TRAINING OF SCIENCE TEACHERS FOR SECONDARY SCHOOLS

### ABSTRACT OF PAPER BY PROF. EDWARD L. NICHOLS, CORNELL UNIVERSITY

In speaking of the training of science teachers, I shall deal with the training of teachers of physics, and assume that what is true of my own science will be found true, in part at least, of others.

The principal weakness in the teaching of science in the secondary schools, at the present day, does not arise from ignorance of method, but from the lack of a mature and well established acquaintance with science itself. It may seem to be demanding much to insist that every science teacher shall be, in some real sense of the word, an investigator; but it is my conviction that only in so far as our science teachers become men of science, in the sense of having the particular science which they are teaching woven into their mental fabric, can we hope for really satisfactory results. For this interweaving of a subject into the mental fabric, much time is necessary, and during this time the subject must be, in a very live and real sense, a topic of thought and contemplation. There must be persistent reading of the best literature on the subject, and this must be accompanied by *habitual experimentation;* for thus only can what is read in science be made actual. The training of science teachers, then, to my mind, reduces itself to the formation in them of habits of serious experimentation, accompanied by reading and thinking about the subject to which they are devoting themselves.

By the term science, in what has gone before, is meant not merely the subject-matter of some superficial elementary textbook which it is to be the fortune of the individual under consideration to teach, nor of any set of such books, but rather that greater domain, the faint and more or less distorted reflections of which we find in our texts. What proportion of the science teachers of this state or of other states habitually read those journals in which are gathered the achievements of research? To read even the best three or four of these journals in a given subject requires a working knowledge of French and German. He who reads English only has his field of vision reduced to a small part of that which he might be privileged to contemplate had he command of the three languages. How many of our science teachers read habitually even the foremost scientific journal in their own department, which is published in the English language? It must be said, I fear, that the great majority of us are in the habit of taking our science in the diluted and ofttimes contaminated forms in which it is doled out to the general public through the popular press, and that scientific reading, other than that of elementary textbooks, is the exception with the science teachers of the secondary schools. Habitual experimentation, other than that which is necessary in the preparation of class demonstration and in the ordinary routine work of the laboratory, I fear, it must also be admitted, is likewise the exception; and yet of the two, experimentation in some serious sense is more important than reading, if the scientific teacher is to develop the best that lies in him.

The fact may be cited, against these views concerning the proper qualifications of science teachers, that very many men who have shown themselves able to further the advancement of science by research, and many others who, while not investigators themselves, are deeply read in the literature of their subject, have failed as teachers. What I maintain is that such failure is not due to their erudition, nor to their powers as investigators, but to some personal peculiarity which would just as surely have prevented their success had they been ignorant or incapable of scientific performance. Teachers, on the other hand, at whose success in the classroom we marvel, when we come to consider the narrowness of their scientific equipment, would be very much stronger than they are if they were men of science as well as teachers. The usefulness of a good course of normal school training to the young man or woman of science who is to be a science teacher, we may take for granted; but, however much those who devote themselves to pedagogy may be able to tell the young science teacher — and it is much, there is a very real and serious danger of diverting the mind at a formative period from the pursuit of science itself by the too long continued and too strenuous insistence on the importance of method. So exacting is science as to the unwavering faithfulness of her followers that the diversion of the mind to other channels of thought, even for comparatively limited periods, will ofttimes produce an estrangement which it requires years of persistent effort to overcome.

Granting that the highest type of science teacher must be in some real sense a man of science himself, must follow the development of his branch of science by resort to the original sources and must cultivate his own scientific powers by continued experimental investigation, let us inquire briefly what training he should have.

The first requisite is residence for a considerable period of time, not less I should say, than the four years usually allowed to college training, in some community where there is a scientific atmosphere. The existence of a scientific atmosphere implies the presence of a considerable number of men who are associated for the purpose of promoting science and whose main purpose in life, finding expression in a multitude of ways, is her advancement. There are many institutions in this country where science is taught, but in too large a proportion the scientific atmosphere is altogether lacking. We find it only where there is a real productiveness. We miss it in those localities where teaching consists simply in the handing down of stereotyped facts, established by former generations of workers, and where no effort is made to push the confines of learning beyond their present boundaries. In too many very respectable colleges in the United States, the attempt has been made to draw a sharp distinction between those engaged in research and those occupied in teaching, and to establish the doctrine that the teacher and the investigator belong to essentially different classes. It is the doctrine of the mentally lazy, of those who would shirk their share in the great labor of scientific research and are glad of any excuse for doing so. It is my conviction that no science teacher, considered simply as a teacher, is at his best unless he takes some part in research; and that this is just as true of the teachers in the secondary schools as it is of teachers in our colleges and universities.

So great, in our day, has the army of scientific workers become, that it is increasingly difficult to push out into the domain of the really unknown. There is something of truth in the prevalent idea that those who would make long expeditions into the untraversed regions which lie beyond the confines of our knowledge, must not only be specially endowed, but must possess in addition to mental equipment ample leisure in which to pursue their explorations, together with extensive and elaborate apparatus for carrying on the work. Of certain lines of investigation, this is true, but by no means of all, and it should not be forgotten that so far as the effect on the science teacher individually is concerned, it will do him much good to reexplore for himself parts of the newly conquered territories of science which have already been traversed by others. In so doing, he will be sure to discover features overlooked by those gone before; and aside from the delights which all such experimentation brings to the lover of science, he will add something to the stock of human knowledge. This secondary research is extremely important. It bears the same relation to the first experiments in any given field as the topographic survey does to the work of the explorer. He who first crosses an unknown tract sees but little of it and his description is necessarily incomplete. Those who come after and work up the details, contribute fully as great a share as the pioneer himself.

Physics, my own science, presents countless minor problems for investigation which can be worked up as well in the laboratory of the secondary school as at the university. The same, I feel sure, is the case in the other sciences as well. Nothing will so soon arouse the interest of school children, nor for that matter, pupils of any age or degree of advancement, as the fact that the teacher is an investigator. Nothing more completely kills the interest of both teacher and pupil in science than the impression, too often prevalent in the minds of both, that the science in question is to be found between the covers of some elementary textbook.

If we are to secure the qualities which I have pointed out as essential to the highest work in science teachers, we must then begin with the institutions whence such teachers are to be drawn; laboring to create the scientific atmosphere which I have already spoken of as essential to all true growth and scientific training. Those who have breathed this atmosphere for any considerable time are more or less permanently affected by it, and, when they go out to teach, there is at least a reasonable prospect that they will continue in the habits which they have formed as students. In too many cases, unfortunately, scientific ambition is a matter of stimulus from without, impressed on the individual by the influence of those under whom he studies and those with whom he associates. Such ambition lacks spontaneity. When the stimulus is removed, it dies. It is one of the sad and discouraging things in the career of those who have to deal with the scientific training of young men and young women to see many who promise well lapse, when removed from the environment of the scientific activities of others to some region of comparative isolation, and drop away from those habits of thought which provoke to investigation.

It is is most important, in view of this fact, that teachers shall be banded together in local associations for the discussion of science, that they shall attend the meetings of the great societies for scientific work, such as the American association for the advancement of science, and that they shall be active, working members of the numerous special national societies for the promotion of the individual sciences. Thus and thus only may we hope to keep aflame the fire of scientific enthusiasm.

I am aware that there are great difficulties in the way of securing for the mass of our science teachers the sort of training I have described. Some of the difficulties which will suggest themselves, I feel sure, to those who hear me, are imaginary. Others, alas, are only too real. It is *not* true that the teacher and investigator form distinct classes, nor that there is any incompatibility in the combination of the two. It is true that the great drawback to research on the part of the secondary school teachers, aside from their lack of training for such work, is the lack of time. But there is no very great discrepancy in this respect between the amount of time at the disposal of those who teach in our college and university laboratories, and those who do similar work in the schools. Every laboratory teacher, whether his work be of the most advanced or of the most elementary character, is a busy man. His hours are of necessity very long. He requires in addition to the preparation from books, much time-consuming and often nerve-wearing experimental preparation. The hardest worked member of many of our largest laboratories is the head, who more than compensates for the smaller number of routine hours which he keeps, by the number of details, pertaining to all the different lines of work carried on under his direction, which he must have within his ken. Both in college and in the secondary schools, a certain amount of time, nevertheless, can be found for original work on the part of teachers; and, if the importance to them and to their pupils of the habit of research were duly recognized, much more time than is at present available would be found by rearrangement of hours, and by the sacrifice of less essential things.

The most notable piece of work in physics that has ever been performed in the state of New York was carried on by a secondary school teacher within the walls of a school building. Some of the wires which Joseph Henry, for lack of a laboratory, strung around the walls of the school chapel of the Albany academy still hang there in memory of the man who would be a physicist in spite of every difficulty. Those investigations are now known wherever physics is studied; and they have served to place the name of Henry among the great ones in the history of science. Within my own recollection there have been two original investigators among physics teachers in the preparatory schools of a single city of this state. One of them, whose name is well known throughout the scientific world, has since occupied chairs in a technical school and in a college, but the period of his greatest production was that of his apprenticeship as a teacher in an institution which was classed among the secondary schools. I may find another example in the experience of a young man of this state who went to the far west to fill a science chair in an institution which was called a university. He found himself, in point of fact, college professor and secondary school teacher in one, for in that day, the institution of which I speak carried three years of work preparatory to entrance to the freshman class, and three fourths of the students were members of the preparatory classes. The plant for the teaching of physics consisted of a badly shaped classroom with lecture table at one end, a small office for the individual who was at once the head and the tail of the department, and a dark passageway leading into the lecture room. Within wall cases on either side of this passage was the collection of apparatus for purpose of demonstration. Laboratory there was none, and the principal use of the lecture table, according to the current traditions of the place, had been as a resting place for the feet of the previous incumbent of the chair, during the periods in which he was questioning his classes on the day's lesson. The teacher to whom I refer, and who for a number of years carried the burden of the instruction of large classes of subfreshmen in addition to the regular college work, and who organized laboratory practice for all grades where there had been none previously, now fills a professorship in a well equipped eastern institution. He is the author of many papers on physics, but at no subsequent period has his scientific productiveness been greater, I am informed, than during these early years of stress; nor have later results, obtained under the easier conditions, been deemed of any greater importance. Valuable as scientific apparatus is, and the leisure in which to use it, with access to great libraries and intercourse with scientific men, the supreme feature of success is, after all, the determination to be a physicist, a chemist, a botanist, etc. at whatever cost. This determination is inborn in the individual. No institution can create it. That it may not lie dormant and undeveloped, certain conditions should prevail. What these are, I have endeavored to point out. In affording these conditions, our institutions for the training of science teachers will be doing all that can be reasonably demanded of them. In so far as they fail to afford the stimulus necessary to the development of the germs of scientific ambition, they fail of their highest purpose.

Such training of our teachers as I have indicated will doubtless be deprecated by some on account of the tendency toward specialization. It has been the fashion to speak of specialists as narrow. Certain it is, and fortunate, that the specialist is not permitted to scratch the surface of the ground over a wide area, scarcely stirring it, but must plow deep. The narrowness of true specialization, however, is something which vanishes on scrutiny. No theme in science is so special but that, if we attempt to get at the whole of it, we are led over an amazingly wide territory. None is so narrow but that it will be found, if pursued in any thorough manner, to tax the powers of the investigator and to call on him for gifts and faculties such as he is not likely to command without a broad training. Languages other than his own he must read if he would master the literature of any scientific topic. French and German will scarcely suffice him; for often he will be obliged to put up with meager translated abstracts of memoirs which he ought to read in their entirety, unless he is likewise able to attack the literature in Italian, Dutch and even the Scandinavian tongues.

The confines of a single science will be found as much too narrow as the limitations of a single language for the purpose of the investigator of even the narrowest problem. If he would interpret his own observations, in whatever science they may lie, he must be something of an experimental psychologist. If his problem belong to the domain of physics, he will find a considerable knowledge of the sister sciences of chemistry and of mathematics scarcely less necessary that an acquaintanceship with physics itself. The natural sciences are so interlocked that, in spite of the division of them, and repeated subdivision into portions to which we give distinctive names, there grows on the scientific world an ever increasing sense of the unity of science as a whole. Biology is but the physics of vital phenomena, geology the physics of the earth's crust, chemistry the physics of interatomic relations, astronomy the physics of the outer universe. The whole of this domain no man can be acquainted with. The whole of it, therefore, no teacher can satisfactorily teach.

Whatever languages and subjects he may be required to teach in the secondary schools, every teacher should have his specialty. He will be fortunate if his subjects are closely allied. In that case, the close relation into which, as a teacher, he is brought with sciences akin to his own, will be helpful rather than harmful to him. When in our schools, science teaching has been properly developed, there will be no excuse in even the smallest institutions for the wasting of pedagogic energy by the scattering of the teacher's attention over too wide a field. Already we begin to find secondary school teachers who are able to devote themselves to one or at most to two sciences; and these are the forerunners. Soon what is true of them will be true of the great mass of our secondary school teachers.

It will be noticed that nothing has been said of the precise curriculum which the student who is in training for science teaching should follow. There should be no course with prescribed details which all must complete. The essentials are easily stated.

These are:

1 An elementary course in each science, *under the hands of a master.*

2 Laboratory exercises, rudimentary at first but always involving measurements, in which routine is left behind as rapidly as is compatible with thoroughness, and in which everything is done to develop originality, independence and the love of research.

3 Seminary work in which the student has the opportunity to hear, discuss and to present, himself, for discussion whatever is new in his science.

Whatever of training in the methods of teaching may be deemed desirable should follow, rather than precede the foregoing. No institution, whether it call itself normal school, college or university, that does not offer the student opportunities of the kinds just indicated, is fitted for the training of the modern science teacher. No institution the members of the faculty of which are not bona fide men of science, devoting themselves quite as seriously and continuously to research as to routine teaching, can hope to produce in its students those qualities and habits of thought that I have endeavored to show are essential to the highest type of teacher.

Finally, I hope that it is clear, from what has already been said, that the training of the true science teacher has its beginnings only in school and college and that, if he is to continue in highest efficiency to the end of his career, he must take research as a part of his regular business and follow it persistently to the end of his active life. That alone, with the stimulus which comes from contact with other workers, will keep him alive. Let other teachers, if it seem good to them, get together to talk of teaching and methods of teaching. *We should talk science;* and I look forward to the day when the pedagogic questions which now engage us in the state science teachers association, and which so far as one can judge from our discussions are already pretty well settled, may be made subordinate to the supreme topic, *science itself.*

**Prof. William Hallock** — I must confess that I felt as I heard Prof. Nichols reading his paper that he had brought me up here as a sort of sample. I do not know whether this is one of the things that the Germans call an *abschreckendes beispiel* or not. The fact is, I feel a great deal of hesitation in speaking about the training of science teachers, because I had been bothering with physics some 10 or 15 years and teaching physics several years in a reputable institution before I heard of "pedagogic values" and things of that sort, and I had to attend one of the meetings in the central part of the state to find out what "apperception and coordination" are. But I have had some 10 or 15 years of solid work in research, so I rather think that Prof. Nichols is going to show by me that a man can become a decent sort of teacher of science without any education as to methods in teaching, if he has done some research work and is trying to do so still. I agree so fully and specifically with the main outline of Prof. Nichols's suggestions that I shall do nothing more than emphasize certain points by repeating them from my point of view. I want to enforce this consideration with reference to the reading of journals, that the journals that ought to be read by us all, and by the secondary teachers as distinctly as by anybody else, are journals dealing with subject-matter. Do not let us spend all our time in discussing methods. Methods are all very well and it is a great comfort once in a while to get together and discuss how this thing can be brought best to the mind of the child, but what is of the most benefit for us and indirectly for the student is the material. The fact that we have got to teach the principle of Archimedes does not mean that we have nothing new to learn with reference to hydrostatics. The subjects may be old, and we may say that we have nothing new about Ohm's law, and the question is how you are going to teach it. But, as Prof. Nichols has said, the attitude, the mental condition of the teacher, is in many respects most important from a pedagogic point of view. The subject-matter is quite as important as the method, because, till the teacher has a clear, clean-cut idea of the subject-matter in all its relations, he can not make it clear to anybody else. I wish to say a word with reference to making things clear — a point that was touched on in the main address. It relates to the distinction between science teachers in secondary schools and science teachers in college; and it may be considered along with the notion, referred to a few moments ago, that education in the secondary schools is something entirely different from education in the college. We are simply doing a different kind of work. One day, as I was discussing the subject of entrance requirements in New England colleges with some friends in New Haven, they said to me, "But you are requiring of the secondary teacher in physics something that you do not know whether you possess yourself. You are requiring ability that is comparatively greater. You want a secondary teacher in the schools to be equal to the college professor." I said, "Not only that; I do not stop there. I know from what experience I have had that it is a great deal harder work, it requires a clearer general grasp of the subject, to introduce into the mind of the student in the beginning an original idea, an original mental concept, than to take a class through a college course after they have got started." It is harder today for me to go into the laboratory with students that know absolutely nothing about the law of refraction, light, etc. and get into their heads the proper ideas, than it is to go into the research laboratory and tell a man how he shall carry on a particular investigation. The two things are to a certain extent of a different kind, perhaps, but the qualification for guiding advanced research follows naturally and necessarily from the other thing. If you have got clear fundamental ideas of a science, then it is only a question of reading and of keeping along with what is going on. On the other hand, if you do not have a clear start, it does not make any difference where you are, you and your pupils will always be muddled. Thus, I think it is natural that I should agree with Prof. Nichols and emphasize the subject-matter, because method is a variable quantity. I remember an old friend of mine in Washington, a patent lawyer. Whenever I came to him with some idea with which I was going to make a fortune, I would explain to him elaborately how I proposed to do it. He would listen very attentively and then would say, "Well, how else are you going to do it?" Well, if I was fortunate enough to have another way, I would go through that. When I had done, he would say, "How else are you going to do it?"; and he pounded into my brain the idea that you never have the best way till you have at least more than one way. My experience in laboratory teaching is that there is no best way to teach a particular thing. Take any of the comparatively simple principles in physics. In teaching in the laboratory you think, "I have a beautiful explanation of that;" and with the next man you try it on, it does not work at all; he does not seem to grasp it. You can not apply your apperception and coordination in that case. On the other hand, you try some method that has been utterly hopeless with the man you have previously had, and that works very well. Sometimes you have to try a third method before you get one that will make the matter clear. So I say there is no best way. There is no way that will apply in every case, and the teacher must have at his fingers' end several different ways, so that the moment he finds that one lead ends in a blank wall, he can take up another. That is why I say it is harder work to teach the beginnings of science. You must of necessity be able to shift your ground at any moment and take an entirely different point of view, lead up to the same idea by an entirely different line of research. I am happy to say that, from what I have seen, particularly within the last few years, there has been a constantly increasing appreciation — not only abstract, but pecuniary appreciation — of teachers of science in the secondary schools; and to a very large extent the question goes back to pecuniary considerations. We are all fighting the same battle so far as time is concerned; and really, I think, if you come down to the matter honestly, the secondary teachers of science ought to be paid more than the college professors, because they have to work just as many hours, do harder work, and have not that glorious distinction of being college professors.

Prof. Nichols touched a very important point in treating this question of research work for the teacher. There is nothing so pleasing to a student in science (to the teacher, I mean now) as to read and then to repeat the experiments, many of them in a comparatively simplified form. It brings us directly in contact with these things, and we feel that there is a bare possibility that by some unexpected turn we may possibly get out into the front row. The repetition of original experiments, original investigations, is sure to bring out a lot of corroborative evidence and new details; and there is nothing that is as gratifying to a scholar as to feel that he is studying under somebody who is contributing to the knowledge of the world. If in your college lectures, or in your advanced courses in the university, it is possible to refer to some research carried on by any member of the department in which the course is given, the students immediately respond with questions, and they inquire about it afterward and want to see the apparatus.

There are just two more points. One is the question of associations. In Germany the associations are occupied largely with the treatment and presentation of new material and employ the method referred to, that is to have the latest work in a particular line looked over and reported on by some member. That method is particularly useful for local associations, where the numbers are so small that it is impossible to have physical research every week or even every month, and still the interest must be kept up. We can not all read all the journals all the time, but one person can keep track of two or three journals and from time to time report on the work presented in those publications. So far as the time is concerned, I am sure you have our sincere sympathy, because we are in exactly the same condition or a great deal worse off. I do not know whether there is any secondary school teacher that has less time for research than I. I think that, if he puts in more hours in routine work and humdrum business, he must find some way of getting more than 24 hours into the day, because that seems about the time that has been accorded to the average college professor in physics. There is always a little odd time, and you can get in a few moments, it may be only here and there. Today I commenced a little experiment at 10 o'clock in the morning and I finished it at a quarter to 6 in the evening, but I got through with it finally. Then once in a while we get a few hours consecutively for actual observation; and, as has been pointed out, many of the greatest discoveries have been performed under exactly these same limitations as to time and facilities that we are all laboring under at present. The idea that the college professor, for example, has particular facilities for carrying on investigations is often absolutely wrong. We are almost as circumscribed in the line of investigations that we can take up as the secondary school teachers. We have not the apparatus. There are hundreds of things that I would like to investigate if I only had time and could buy the apparatus. We are all together, and this line between the science teachers in the secondary schools and the college professors is disappearing and ought to disappear. The particular occupation a man is in ought not to have anything to do with his scientific standing. If he is doing honest, first-class work in a subject, that is all that is necessary. Whatever he adds to that work will give him scientific standing, and he must stand for his scientific reputation on the work that he does.

**Prof. E. W. Wetmore**—We owe to Prof. Nichols a great debt of gratitude for the way in which he has pointed out one side of this preparation for the teacher; and I am reminded of an old saying that has considerable wisdom in it which is expressed in words something like these: "This ye ought to have done, and not to have left the other undone." In considering the training of the science teacher, we need to go back to what he is doing, compare that with what he ought to do and ask ourselves the purpose of a high school education. Its main purpose, as has been said already this morning, is not to prepare for college, but to prepare the mind of the pupil for his life's work. If he goes to college and gets a better preparation, well and good. If he does not go, still the purpose of the high school is to train the mind of the pupil in the best way possible for life work. Now what is the education which will accomplish that? We have gotten past the time when we thought that education is stuffing, as you stuff a turkey for roasting. It is not pounding so much knowledge into the head of the pupil; it is something more than that. We have gotten past the dogma, "knowledge is power." Power is something more than knowledge. Education means to us something more than to acquire facts, it means gaining skill to use facts. What do we mean by skill in science? A knowledge of all the theories in the world will not make one skilful as an engineer, and a knowledge of all the theories in the world would not make one skilful as a teacher; a knowledge of all the theology in the world will not make a man successful as a winner of souls. It needs skill, and skill is something more than science and more than knowledge. Skill is the art of doing the thing right with the least conscious mental effort; and that art is only gained by practice. Skill is habit crystallized; it comes only by habit, the habit of doing a thing in the right way over and over till instinctively you do it right and can not do it wrong. When an engineer gets into a crisis, he does not have to apply his theories, he knows by a sort of instinct what is the thing to do and does it. That is because he has acquired the art by long practice and thinks quickly. Science lies at the basis of art, for the highest art is never attained without science, but science itself does not give art. On the other hand, a knowledge of the facts does not give the art, however great the equipment of these facts may be. If that is education, and that is what I take it to be, the getting of skill for purposes of life, not for purposes of a particular study, the place of the teacher in school is to help to that skill, and the place of the science teacher is to develop skill in one line. We hear that education is the "harmonious development of all the faculties," but the trouble with a great deal of our education is that every teacher in every subject tries to develop harmoniously all the faculties at once, with the result that he does not develop any. The science teacher is to be responsible for only one side of that development, and, if he can accomplish that, he will have done a grand thing in the evolution of the young mind. Therefore science should be taught as a means and not as an end. A great and very general fault in science teaching is just that thing, that it is taught as an end, as if the great end of study were to know the things. No, no, it is a means and not an end. It is a means in the training of the mind in the best possible way. When such a mind is trained in reference to science, what is its attitude? It is this: that the person with the trained mind is able first to see *the* facts, and that is not simply being able to see facts; the facts not only in the laboratory, not only in the particular experiment, but the facts in the world all about him; to think about those facts and as a result of his thinking to deduce correct principles.

Again, the mind should be so trained that it is able to detect false relations in new facts, to propose new principles which are being continually brought up. To detect the false is quite as important as to find out the true. Also the mind should be so trained as to see God in everything. A workman is known by his works. I heard the assertion yesterday afternoon that the science teaching in the state of New York does not result in absolute perfection. When the students come up to us there is apt to be in the first place a lack of knowledge. I remember experiences with classes that were learning methods in physics, whose members included high school students and college graduates. When I try to probe into their minds for some knowledge of facts or knowledge of principles on which to base a proper method of teaching, these are not there. When I wanted to illustrate a certain point of inductive method to one class of college graduates, I asked them to state Newton's law of gravitation, and there was not one in the whole class that could state it. I said, "What is Boyle's law of pressure?" Not one could state it. "Well," I said, "if you can not give that, tell me what is the law of the intensity of light." I could not get even one of these laws from them. Finally, after a great deal of thinking, one gave the law of light and the rest all knew it immediately; they had heard of it before. Then, in addition to lack of knowledge, I find lack of grasp of principles. I do not mean ability to state a principle, I mean such a grasp of the principle that it is a thing of life, of which one can make some sort of application. I find that almost universally. But still worse, I find a woful lack of interest and of desire to know more about any of these subjects. That is the condition. I have said the workman is known by his work. If that is so, what kind of workmen are they that are turning out that kind of material? Where is the fault? It is not our purpose to go into this in full, neither would I venture on wholesale criticism, but, if we are to have good results, we have got to have teachers trained till they are skilful in the art of education. It may be true that a poet is born and not made; it may be true that a musician is born and not made; and we hear that teachers are born and not made. But there is not one, the poet, the musician or the teacher, who has become skilled without hard, painstaking, careful work, learning how to do the thing. When we say one is born a teacher, we mean simply that he is born with the special capacity of becoming a good teacher. What we want is to take those who are born to it and give them the best equipment possible.

How do these things stand related to training of teachers? Why! knowledge to the individual is the tools with which to work. Power is the skill, the ability to use those tools. You might have the whole equipment of schoolteacher's tools, you could not turn out a fine student. There must be skill behind it. And the person with all the skill in the world could not make a student without the tools to work with. The teacher is the workman and the children are the material. The tools with which he works are the facts, truths, conclusions, the equipment of knowledge and the skill to use it. He needs to have both things; so I make this final point — that the training to which we ought to look toward, which we ought to ask for now and which by legislation ought to be insisted on in every high school in the state of New York, should be in the first place the equipment of scholarship, which means not merely facts and principles in the mind of the teacher, second, an enthusiasm which will lead him to inspire the pupils to be continually on the outlook for new investigation and finally a thorough professional training in the use of those tools which he has, that his handiwork may show the fine finish of the artist, not the crude marks of the bungler.

**J. E. Peabody** — I have been much interested in Prof. Nichols's paper and in the discussion that has followed. I am sure that these university professors have not intended to set up for us who are engaged in secondary school work an almost impossible ideal; but note this array of requirements that has been presented as essential for success in science teaching. First, the teacher must read original articles bearing on this subject in English, French and German publications; secondly, he is not to repeat routine demonstrations only, but must devise and test methods of his own; and in the third place, he must have the habit of research in connection with his teaching. These and other requirements are certainly desirable, but are they attainable?

Let me, if I may, refer to my own experience. On leaving college I entered on high school work with the expectation of finding considerable time for research. With youthful enthusiasm I made known this expectation to my principal, and received this reply: "Young man, if you decide to remain in high school work, you must of necessity give up your plan of doing any considerable amount of research work." I regret to say that I have found this statement of the case altogether too true.

Is not the situation for most of us something like this? We deal with a succession of classes, numbering 30 to 40 pupils, from 9 till 2 o'clock each day, and during the recitation period we must, if possible, keep the attention of each pupil; at the close of school we must take time to look over work with various students; then apparatus must be set up, material obtained and prepared for the next day's lessons; and, after the inevitable papers have been corrected and lessons reviewed, how many of us have the energy and enthusiasm necessary for research? I do not mean that the teacher is not to do advanced reading and study in his subject; but original research seems rather too much to expect from a teacher, while engaged in high school work.

The situation is not hopeless, however, for in the summer vacations many opportunities are given for carrying on advanced work. This is specially true in biology. At the marine laboratories at Woodsholl and Coldspring Harbor gather from all over the country many of the leading biologists. After five years' experience in these summer laboratories, I know that one gets lasting inspiration from work with these leaders of biologic thought.

### Friday afternoon

### SECTION MEETINGS

## Section A. BIOLOGY

### Equipment of the secondary school laboratory

**Inspector A. G. Clement** — When I was asked to take charge of this section and to speak on the equipment of the secondary school laboratory, I was at first at a loss what to do. It occurred to me that the mere recitation of the things required in a laboratory would not be of much interest; therefore I thought I would endeavor to furnish partially a laboratory such as every secondary school should have. Working on that line, we have corresponded with different individuals in regard to lending apparatus and have also seen different speakers who have agreed to talk, and the result is that we have brought together some apparatus of different kinds for you to view while we talk about it.

The first topic is laboratory plans. There seem to be three different arrangements of biologic laboratories. I have a plan here that shows an arrangement in which the tables are placed in front of the windows, and another in which the tables are in the middle of the room. The third arrangement is a combination of the other two. [Several plans and photographs of laboratories were shown.]

The next point has regard to reference books, which would be of use to those teaching biologic subjects. The list is as follows:

### REFERENCE BOOKS

#### *Physiology*

Atwater, W. O. Foods: nutritive value and cost. Farmers bulletin no. 23, Dep't of agriculture, Washington

Blaikie, William. How to get strong and how to stay so. Harper

Kirke, W. S. Handbook of physiology. Blakeston & Son. Philadelphia

Kotelmann, Ludwig. School hygiene. Bardeen

Lagrange, Fernand. Physiology of bodily exercise. Appleton (Internat. sci. series)

Maclaren, Archibald. Physical education. Oxford univ. press, New York

Martin, H. N. Human body; adv. course. Holt

Peabody, J. E. Laboratory exercises in anatomy and physiology. Holt

Smith, Edward. Foods. Appleton (Internat. sci. series)

Sykes, F. J. Public health problems. Scribner

#### *Botany*

Bailey, L. H. Lessons with plants. Macmillan

Campbell, D. H. Lectures on the evolution of plants. Macmillan

Darwin, C. R. Power of movement in plants. Appleton

Detmer, W. Practical plant physiology; tr. by S. A. Moor. Macmillan

Gage, S. H. The microscope: an introduction to microscopic methods and histology. Comstock pub. co.

Ganong, W. F. The teaching botanist. Macmillan

Gaye, Selina. The great world's farm. Macmillan

Goodale, G. L. Physiologic botany. American book co.

Gray, Asa. School and field book. American book co.

Kerner von Marilaun, Anton. Natural history of plants; tr. by F. W. Oliver. Holt

### *Zoology*

Comstock, J. H. Insect life. Appleton

Darwin, C. R. The origin of species. Appleton

Furneaux, W. S. Life in ponds and streams. Longmans

Houssay, Frederic. The industries of animals. Scribner

Huxley, T. H. Introduction to the study of zoology, illustrated by the crayfish. Appleton

Kingsley, J. S. Elements of comparative zoology. Holt

——— Riverside natural history. 6 v. Houghton

Orton, James. Comparative zoology. Harper

Romanes, G. J. Animal intelligence. Appleton (Internat. sci. series)

Semper, Karl. Animal life as affected by the natural conditions of existence. Appleton (Internat. sci. series)

There is not very much to be said about apparatus; look around and you can see it. Here are compound microscopes for the study of lower forms, also charts to illustrate. In buying charts get those which represent the animals or plants you expect to study. For zoology here are specimens preserved in fluids, and also skeletons for comparative study. As in the case of the charts, buy only those you will need. Then you will want dissecting microscopes, instruments for dissecting and a supply of glassware. Here are some micro-photographs, showing enlargements of microscopic objects.

Dr Dodge said yesterday, it is not necessary to have a laboratory to do laboratory work; all that is necessary is a pupil, a teacher and a specimen. So I would not have any teacher think he can not do work if he has not the full equipment. Do the best you can with what you have. Gather round you instruments, books, etc. which will help, the more the better. A large museum connected with the school is good of course. It is always good to get as many specimens as possible. Students should be encouraged to bring specimens, which should become a part of the high school equipment. It is also a good thing to have a bay window where you can grow plants. You will find that you can raise plants which will prove very useful. In fact almost any plant has some interest. I would also have collections like this, illustrating mimicry. [Specimens shown]

In your zoologic laboratory work you will want a vivarium in which you can have animal life. In some schools they are introducing cages as a part of the apparatus. In one place I visited there was an owl in a cage and the students were making observations on it. You also need in teaching botany an aquarium in which lower forms of plants as well as smaller animals may be grown. An incubator is also a very useful piece of apparatus. You can buy one for $5. Watching the growth of the chicken developed therein is very interesting. You also need other apparatus, such as birds' nests. These sometimes serve to illustrate the habits of birds. Anything which will illustrate their habits is good to have; for instance, a piece of wood from a tree where a woodpecker has bored a hole. Also some material to illustrate the economic side, like whalebone, ivory and different kinds of leather.

Of course you will want slides and material adapted to the course of study laid down by the New York state science teachers association. Such material is excellent and can be procured from any botanical supply company. Models of plants are also excellent, but they are expensive and have to be imported.

Then economic material to illustrate the subject of botany is desirable — flax and cotton and such things as would naturally interest students. In the physiologic laboratory there should be models of different parts of the body. Another important thing is the study of the composition of foods from prepared specimens; for instance a pound of cheese separated into the different kinds of food it contains, each kind being put into a separate bottle. This study is very popular, interesting and useful.

After all, no matter how much apparatus you may have, it is nót worth much unless it is used. I have visited schools where I inspected the apparatus. I have one in mind now where the apparatus is beautifully kept, put up in a glass case, always kept just so clean. I have never seen it in use; it is there evidently for the mere purpose of exhibition. The teachers know that the school should be well equipped, as it is, and they take pride in showing how well the apparatus is kept. It revealed no signs of use whatever. I would rather see apparatus that has been used, properly used, not broken to pieces, but which shows proper care.

So it is possible to have all this apparatus and have a teacher there who does not use it. In such a case the apparatus is lifeless. However much we may say about apparatus and equipment, it all depends on the teacher, the first thing needful. A good teacher will gather the apparatus around him in some way. He will get his pupils interested, they will talk it over with the parents, and the latter will finally give the money necessary. Get plenty of apparatus and by and by a laboratory will be provided.

I suppose you have all heard about that celebrated school which was kept for a short time off the coast of Massachusetts.

On the isle of Penikese,
Ringed about by sapphire seas,
Fanned by breezes soft and cool,
Stood the master with his school.

The master was Agassiz. There he established a school, and it is said that this school, though he was there as the director only one summer, has had more influence on the science teaching of this country than any other school that has ever been established.

There were present during that summer as students such men as Dr Jordan, Dr Brooks and others who have become distinguished. It was held for three months only and was to be opened another year, but during the winter Agassiz died. The students returned another year with other teachers. They were good teachers, and affairs went along in a certain way but there was not the same animating spirit, and there were not the same results. After the second summer the school closed, and no more sessions were held. It lacked the inspiring spirit of the great Agassiz.

I observe that those who are invited to address us are here. Therefore I will close my remarks and give way to the next speaker.

### Management of laboratory classes

**Prof. G. F. Atkinson** — When first requested to open the discussion here, I supposed the object was to continue the consideration of the subject presented at the meeting held in New York last winter, the conditions of entrance requirement in the college. This explains the presentation of the thesis mentioned in the program. Afterward I heard that it was the desire to make this a practical not a theoretic discussion.

It is not an easy matter to speak on the management of laboratory classes. As I take it, it means the management of laboratory classes in the high schools. One who has for 12 or 15 years been interested in the management of such classes might be considered competent to speak. If I could make my own conditions, conditions similar to those in Cornell where I have charge of certain classes, it would be a comparatively simple matter to speak; but the conditions in high schools are very different from these. Very few high schools, as you know, attempt anything like laboratory work; very few of them have laboratories equipped according to any one of these plans which Mr Clement has spoken to you about. The one shown you from Middletown high school is almost ideal, I should say. But we find all variations of conditions, from those extremely good to those extremely bad, where there is no room which can be used for laboratory work. Shall we wait till we can have a separate room fitted up ideally, or start at once under the conditions which exist? I believe it is more important to get the laboratory work started under any conditions, and it seems to me Mr Clement struck one of the keynotes when he said the first thing is to get a competent teacher. That is most important, not only in fitting up the laboratory but in the management of laboratory classes. A teacher who has had some experience, if not in teaching, at least in doing laboratory work, so that he is familiar with the practical side, is very necessary. It is difficult for a teacher where the conditions are against him, with no room and no apparatus, but when the teacher is prepared for the work, some way will be found. That is possible under almost any conditions. Temporary laboratories could be made by simply introducing into an ordinary room, boards on the tops of desks, as we do in one of our classes in Cornell. It is necessary in our beginning class of 50 or 60 to do this. Six table tops laid on the backs of the desks make very good tables, and we can have 20 or 30 students at the tables. We usually divide the class into two sections. At the close of the laboratory period, if it be necessary to use the room for some other purpose, the boards are taken off. It works much better than you would think.

With reference to the management, the conditions vary also and it is almost impossible to lay down any one set of rules or any several sets of rules which might answer. It is an important thing however to have the work in the first place well planned. The time to be given up to the conducting, say, of the work in studies with plants should be determined; the number of periods to be given up to laboratory work during that time should be known, and each one of these periods should be planned for in advance. This should include the direction and planning of the apparatus which is to be used for various experiments, the planning of the topics which are to be taken up on different days and the selection of the material. As far as possible, have all material to be used on hand, and material which is prepared from time to time, the plants, etc., should always be ready. It should be so well planned that you will know just how much material it will require for certain demonstrations or exercises and have it ready for the classes on a certain day. Have that all scheduled. This will save the teacher a great deal of worry and it will bring in the different topics without confusion at the time for which they are scheduled. In this way also it will be possible to arrange a course of work which will be logical and will cover the amount of ground desired. You may wish to dwell more largely on certain topics than others, and if the work is all planned in advance, you will know just how much you can cut out if necessary.

In the high school, I should judge that one of the greatest difficulties is the handling of large classes by a single person. How can a single teacher manage a large class or a large number of pupils? I don't know that I can answer that, but it is one of the difficulties we ought to face and discuss. Planning the work is one remedy; carefully putting away the apparatus when you are through is another. Don't depend on the apparatus which you have to borrow from some other laboratory. Have it put away, so when the time comes you can put your hand on it.

Then it will be very desirable if it can be accomplished, and I believe it can, though many teachers will not think so, to have different periods from the regular ones which now exist. That is, instead of a single period for laboratory work, combine two periods. I presume nine tenths of the teachers will say, it can not be done because it will break up our existing methods; but a great deal more can be accomplished in a single period of 90 minutes than in two of 45 minutes. The teacher goes to the trouble of getting out the apparatus, and this would take no more time for a long period than a short one. These periods of course could not be scheduled so often as at present. Say they might come every other day. And, if the class were large, it might be divided into sections. I presume conditions vary and a certain arrangement which some schools might find it suitable to adopt might not be the best for others.

The main thing is to introduce the laboratory work, and then let each institution develop the method of work best adapted to the conditions surrounding it.

**Prin. C. W. Richards** —Do you know of any good laboratory nearer than Middletown, that can be visited?

**Inspector A. G. Clement** — Yes, Utica has a good laboratory.

**Prin. C. W. Richards** — Is it desirable to have botany, physiology and zoology in the same laboratory?

**Inspector A. G. Clement** — I think you could use the same laboratory by changing round your material. It is preferable however to have separate rooms if you have money enough and pupils enough.

**Prin. C. W. Richards** — Do you think it is practicable to put two periods into the laboratory one day and take on the alternative day algebra, perhaps, applying the same rule of adding two periods together? Will that be feasible?

**Inspector A. G. Clement** — You must be guided by circumstances. I think it can be managed.

**Inspector E. W. Lyttle** — That is a practical question, it seems to me. I have met it often, and it is one that can be easily answered where the principal can educate his board of education or the public to a correct view of the work of the high school. The matter is very simply disposed of if we somewhat lengthen the high school day in this way. If from 9.30 to 1 we have that part of the high school work done that does not involve laboratory work at all, and we save the afternoon for laboratory exercises, for manual training, cooking classes and whatever work demands more than 45 minute periods, letting those who are not engaged in such work come to study, it will solve the whole question.

**Miss L. B. Palmer** — I have had some experience in this line with a principal and a superintendent who were in sympathy with thorough and modern methods in science teaching. It was assumed that each pupil would ordinarily require 45 minutes' preparation for class. The program was so arranged that pupils had a study period immediately before or after their science recitation or quiz. At the teacher's discretion no home study was assigned, and she was at liberty to combine the two periods for laboratory work.

**Prof. H. A. Surface** — I have found it advantageous for the teacher to have a vacant period before the laboratory period in order that he may look over the laboratory material. He should if possible have his laboratory period come at such a time that he will not be driven up to the last minute.

There are two questions to be answered. How are we to obtain the material that we need in zoology? at whose expense? If the board of education is to pay for it, how are we to educate them up to this?

Then, after we get the specimens, how are we to use them? Shall each pupil be supplied with a specimen, and, if so, how shall we manage the direction of large classes of 40 or 50? Am I to have a chicken before each pupil or one chicken for all of them?

**Inspector A. G. Clement** — I think the board ought to pay for the material. It depends on the skill of the teacher to work up sentiment. It will have to be done gradually.

**Prof. H. A. Surface** — It seems a good deal to ask them to buy material for dissection which is finally thrown away. We ought to be satisfied with what they do give us, laboratory equipment, specimens, etc. We have a museum and material that can not be brought today for $1000. They bought a large quantity of minerals, ores, etc. of the greatest value, but it is permanent material. We have a better equipment, I think, than any other similar institution in the state. To ask in addition to the material we have — microscopes, books, etc. — this perishable material to be dissected and thrown away, is a good deal.

**Prof. C. W. Dodge** — Why is a chicken necessary?

**Prof. H. A. Surface** — I find that parents do not object so much to chickens as to cats.

**Prof. C. W. Dodge** — Couldn't sparrows or pigeons be used?

**Prof. H. A. Surface** — I think the English sparrow can be used.

**Prof. F. W. Barrows** — In the central high school in Buffalo, with very little equipment and few laboratory facilities, we have have been able to do a great deal in the course of two years by taking $1 a term from the pupils who do the work. I was surprised at the amount of material and equipment we could get with that dollar, having from 20 to 60 pupils a term. We had quite a little surplus last term. We bought some museum specimens, dissecting instruments, etc., and quite a number of specimens for dissection and have still some money left.

**Prof. C. W. Dodge** — I had some very large classes when I commenced to teach in the Detroit high school. I had from 100 to 120 pupils each day and five periods of 45 minutes each, the school session lasting from 8.30 to 1, with an intermission, each teacher usually having one vacant period. We had 10 microscopes and a room about like the one we are in at present. I had usually 20 pupils, sometimes 24 in each section. The problem at first was how to give those pupils laboratory work and recitation work and keep them all going at once, specially with microscopes, as these were not binocular and two persons could not look in at once.

I had some tables put endwise at the four windows, that accommodated five pupils each, then on the other side of the room were the ordinary recitation benches and blackboards. I divided my classes into subsections of 10 each, 10 to go to the microscopes and 10 to recite, so that each student worked at the microscope every other day and recited on the alternate days. When the section came into the room, the 10 who were to work went to the microscopes and commenced to get their material ready.

While this half of the class were getting ready for their work, the other half would go to the board and make drawings of whatever they had seen the day before, naming each part represented. A glance at these drawings would show at once how much each pupil had seen and whether he had really comprehended what he did see. It would take them 10 or 15 minutes to get the drawings on the boards and during that time I could look over the work of the 10 at the tables and see that they were started. Having once been started, they could work through the laboratory period without much more attention, though once in a while some difficulty would arise and I would have to help out. So by the time those at the boards had finished, I was ready to hear them recite. Then during the change of classes I examined the drawings on the board. The pupils left their names on the drawings, and I could see exactly what each had done. It was not an ideal mode of conducting a class but it was the best I could devise under the circumstances.

**Inspector A. G. Clement** — Those are good, practical remarks.

**Prof. F. W. Barrows** — In every exercise that we call a dissecting exercise I take pains to provide every pupil with a specimen. It is the only way to success. The students examine a few types without dissecting them, in which case I make the dissections myself — if possible two or three — and exhibit them to the class and speak of them. I would of course prefer to have each do his own dissecting.

My divisions are not so large as those Prof. Dodge had to handle; and frequently not only one specimen but two or three are at the disposal of each pupil. It is well to provide so many beforehand that, if a pupil spoils one specimen, he may try another.

**Prof. C. G. Rogers** — I have been thinking about laboratory equipment and the arrangement of laboratory tables specially. Some few things that have occurred within the last two or three years make me think that a teacher does not necessarily require a laboratory room in order to do creditable laboratory work. Three years ago we were badly situated here in Syracuse. We had a small 7 by 9 laboratory room, and our classes became so large that we could not accommodate them at all, and were forced to fence in a back porch on the Hall of languages and use that for a laboratory. It was just about as well equipped for a cold storage box. But some very creditable work was done there.

Since we came to this building I have been impressed with the fact that laboratory tables may be arranged in two or three different ways. In this room tables are set with the ends toward the windows and there are also tables along the wall at the end. The great difficulty with tables situated with the end toward the window is that in a corner much space will be lost if the room is lighted on two sides and it is necessary to make use of all the windows for laboratory work. The laboratory next to this is much better arranged as to tables. There are tables along the walls, and a long table through the center of the room. I have succeeded in directing 16 persons in that room much easier than 12 in this room. The laboratory at the other end of the building accommodates admirably 24 at a time, but I find that one person can direct 16 in this small room in this end of the building just as well, or better than two can look after 24 in the room at the other end. In this next room the students are all where the instructor can have his eyes on them all the time; it is impossible to get more than 20 feet away from any person in the room, and that being so the work is focused at one point. A person can ask a question in a low tone of voice and the instructor can hear and answer without stirring, while in a long room it is necessary to travel the length of it to instruct some one at the other end. A small room lighted on two sides, with tables at the walls and through the center, seems best for our purpose.

**Prof. W. D. Merrell** — I have been through the mill to a certain extent in the zoologic laboratory. The first I had was equipped with benches, with stationary writing desks, and the first laboratory table was a board laid on one of these arm rests, the pupils being distributed round the room as for recitation, simply spread out a little more. But we had the specimens and we had the students. I had no trouble in getting my boys to bring in material. As for providing clams or grasshoppers or any of those things, they brought in all I wanted and kept us supplied indefinitely. I found that after I had gone through one year with that sort of equipment in the laboratory, the school authorities were very willing to get me some small tables. The room was lighted from one side only and was square; so I had to have the tables through the room. I believe my laboratory developed as fast as I developed in the teaching. I believe that will always be the case.

**Dr E. J. Durand** — You all know that the life processes of plants are dependent on protoplasm. In quite a number of plants the presence of protoplasm may be exhibited clearly. One of these is *spirogyra,* one of the lower *algae.* It is necessary, of course, for the student to have a microscope in order to study this substance, to determine its characteristics and relation to the cell. It is possible, however, to make preparations of this plant on slides, and to put them where they may be examined by quite a number of pupils, 15 or 20, all using a single microscope.

There are other properties of plants which may be studied very appropriately in connection with *spirogyra,* and may be demonstrated to large classes to good advantage. For example, the osmotic activity in the cell, or the principle of osmosis, through which plants are enabled to obtain their liquid nutriment. One may demonstrate this with the aid of the microscope, carrying on the process so gradually that it may be seen by quite a number of students in succession. In doing this one should mount a few threads on a slide in ordinary water. Then a 5% salt solution should be placed at the edge of the cover glass and drawn under it slowly by means of filter paper. When the salt solution comes in contact with the cell, osmotic currents are immediately set up between it and the cell sap. This takes place through the wall layer of protoplasm, which acts as a membrane, the salt solution outside being the more concentrated the greater the outward current, with the consequent formation of a partial vacuum within the cell. As a result, the membrane and other cell contents begin to draw away from the wall and to shrink toward the center. This may be easily seen by several if produced slowly. If the salt be then washed away with fresh water, the greater osmotic current will be inward, and the membranes and cell contents will expand to their original position.

[The speaker then performed some experiments with slices of beet, and with celery, to demonstrate the relation of turgidity of cells to the rigidity of plant parts.]

I have in these vessels some slices of the ordinary garden beet. It is not necessary to get costly plants with which to demonstrate these principles. Here is a section of beet which has been kept in fresh water. It is stiff and rigid. The cells have taken in water from the outside by means of osmosis till each is in a state of turgidity. The whole section is turgid. Here is a similar section which was placed in salt water. It is soft and pliable. The cells have lost their turgidity through osmosis. If we put the slice in fresh water, it will soon become rigid again.

Take this piece of celery. By pulling off the epidermal tissues from the outside one can see some of the reasons for the rigidity of stems. The stem is at first stiff and rigid, after the epidermal layer is pulled off the medullary portion becomes so flabby that it may easily be bent. This rigidity of the stem is the result of the tension exerted by the epidermis on the outside and the turgidity of the tissue within. The cells of the latter becoming turgid, and pressing one against the other, it tends to lengthen. This tendency is opposed by the rigid epidermis. The result of the two opposing forces is the rigidity of the stem. A dandelion stalk shows this nicely. If it be split and the strips put in fresh water, they will curl up very rapidly. If put in salt water, they will straighten out again.

One should also experiment with root-hairs of plants. If they be placed in salt water, the protoplasmic contents will shrink away from the wall. If they be placed in fresh water, the protoplasm swells out again. Such an experiment demonstrates osmosis in these organs, and has an important bearing as showing how plants obtain water and dissolved substances from the soil through the root-hairs. Many of these experiments are such as can be performed as easily in the woods as in the laboratory. They require only ordinary, everyday plants, and may be shown to large sections.

**Prof. H. M. Pollock** — What do you think of the solar microscope as an instrument in demonstrating?

**Prof. Atkinson** — I have never used that.

**Prof. Pollock** — We have no regular laboratory in Albany, and so we have been obliged to use the solar microscope; but I doubt its value as compared with the regular laboratory microscope. Still we find, in showing blood corpuscles and other single-celled forms, that we can represent them quite well, and we have to use it as a substitute.

[W. A. Murrill showed a number of specimens of pressed plants, plants represented on slides and plants preserved in formalin, which would show the pupil the ascending scale and the position of each plant in the scale.]

## Section B. PHYSICS AND CHEMISTRY

### Equipment of secondary school laboratory

BY PROF. E. R. WHITNEY, BINGHAMTON HIGH SCHOOL

In far too many secondary schools the laboratory is a sanctum sanctorum, entered only by the teacher and a few select student illuminati, and individual laboratory practice is an untried venture. The pride of the citizens of the place over a few grimy bottles chock-full of mystery, so ancient that the corks and labels are disintegrating, and over a museum of Aztec and Egyptian apparatus, is truly wonderful. So long as the local authorities are content with the equipment of their school, the science teacher must continue to degrade his profession by omissions, or resort to makeshifts and expedients that are not only desperate, but humiliating. Poor equipment lessens teaching effectiveness, and increases the difficulty of discipline and class management.

In the time allotted for this paper, I can do little more than enumerate some of the many requisites for the construction, furnishing and equipment of a secondary school department of chemistry and physics of such character as is demanded by modern science teaching. Many of the schools of the state have such equipments. For others, there is hope.

### *Location and general specifications*

Six rooms are necessary — a lecture room, a dark room for photography, a chemical laboratory, a physical laboratory, a preparation room or teacher's private laboratory, and a storeroom.

The basement may be an advantageous location for the physical laboratory, on account of the facilities afforded for secure supports, but it is usually a dark, moist place, and is hardly to be chosen. The location of the chemical laboratory is an unimportant matter if the building is properly ventilated. A south light for the physical laboratory and the lecture room is to be desired.

The floors and partitions should be made effectually soundproof with double ply sheathing and deafening quilt. Floors of any wood, when moderately treated with dustless oil or an elastic floor finish, are easily kept clean and do not allow dust to scatter. One master key to the locks of all doors, and another to drawers and lockers, will do away with the necessity of carrying about a huge bunch of keys.

Whatever the system of steam heating, though I prefer the indirect, or direct-indirect radiation, ample provision should be made for obtaining hot water and live steam from the pipes. Every room should be piped for gas to light the room and supply the Bunsen burners, piped for water, and wired for electricity — both battery and dynamo currents. The latter should include all varieties of electricity the town affords.

### *Lecture room*

The lecture room of the secondary school need not be large, but it should be provided with all the necessary conveniences. The secondary school science teacher is called on to teach many subjects. The school program seldom allows him the time necessary for preparation of the lecture experiments. The lecture desk, therefore, should be large, so that apparatus set up for physics and chemistry may stand unmolested through other periods. Let one portion of the desk be devoted to chemistry, another set apart for physics and another for botany. No iron should be used in the structure; glue, dowels, brass, and mortices are good substitutes. The chemicals must be thoroughly isolated from metal apparatus, so that corrosion can not occur. Glassware and metal ware can not dwell together in peace and harmony, except under the rule of a rare demonstrator. It is prudent to have separate drawers and lockers for them.

Nothing can supplant systematic experimental lessons by the instructor, when accompanied by searching recitations. Much of the success of the laboratory practice depends on the worth of the lecture and recitation. Therefore, every condition of easy control should be considered, and every detail in the physical environment of the lecture room should assist the instructor to give his undivided attention to the presentation and the drill.

Running water in proximity to the lecture table is a necessity. A high-necked faucet for filling cylinders, etc. and a connection where water motor can be attached, are desirable. A pneumatic trough with glass sides has obvious advantages over the tinware contrivances. One of the most important features of the lecture table should be the device for removing the obnoxious gases and vapors generated by chemical experiments. A funnel-shaped, galvanized hood for catching gases that ascend, and a grating in the table top to allow the escape of those that descend, when connected by suitable pipes to an exhaust fan, have proved efficacious. I have generated a profusion of chlorin before the class, and pupils in the front seats even did not detect any odor till a flask of chlorin was passed about the class.

Settees with arms are satisfactory seats when placed on three foot platforms having a three inch rise, the rise of each platform increasing one inch toward the rear. Good blackboards at the front and on two sides, will be of more than ordinary value, if the chalk troughs are at least three inches deep, and are covered with half inch, mesh wire screens to sift out the dust and small pieces of chalk.

The stereopticon is indispensable. It is said that an ounce of picture is worth a ton of talk. An inconvenient stereopticon outfit may be a decided drawback. Let everything that pertains to the manipulation of the stereopticon be in one place — the back of the room. By means of a crank, the cords attached to opaque shades may be wound on a cylinder and all of the windows darkened at once. If the wall above the front blackboard have a white finish, the screen is always ready. Let the stereopticon be on a slide cabinet of suitable hight, the top of which is arranged so as to tilt up or down and swing around on a pivot. Drawers in the cabinet should be of correct size to contain the slides and accessories. The slide cabinet should be equipped with oxygen, hydrogen and illuminating gas, battery and dynamo currents, and should have an electric signal operated from the lecture table.

### *Dark room*

A good-sized dark room, supplied with running water and a sink, clearing, toning and fixing baths, trays, shelves for photographic reagents, a case for dry and lantern slide plates, a good ruby light, and a passage allowing entrance and exit without exposure, will be of the utmost advantage.

### *Chemical laboratory*

The chemical laboratory should be in a room by itself, unless the most perfect and adequate ventilation is secured to save metallic apparatus from corrosion by fumes. The chemical laboratory may be provided with cases around the walls for chemicals, bottles, corks and other supplies, though these might better be kept in the stock room. The chemicals should be arranged on the shelves in alphabetic order, and numbered, for easy finding. A small case for student notebooks should be placed near the door. A blackboard for specific directions to the class, should be located in a conspicuous position. The pupils' desks may be three feet high, and in double rows facing each other. Each pupil should have, for storing apparatus, at least one locker and two drawers. A recess for waste-jar and the stool when not in use, is needed. Almost any wood will do for the desk top if thoroughly oiled with linseed oil, and then treated with paraffin or floor wax to make it waterproof and nearly chemical proof, though the ideal substance is tile. Vertical gas mains coming up from the floor through the desk and ending with four hose attachments, one for each of four students, are preferable to the horizontal pipes on the desk top. One 10″x16″ sink, with water faucet, will suffice for four pupils, and will serve as a pneumatic trough when the strainer over the waste-pipe is covered with a large piece of sheet rubber. Iron shelves with several one half inch perforations, complete the pneumatic trough. The faucet should have a thread for hose-coupling, for a filter pump, etc. One test tube cleaner hanging by the faucet, will do for four pupils. Either nonsiphoning or the McClellan traps in the drainpipes, will be an acceptable substitute for the usual plumbing board regulation in regard to overhead vent pipes from each sink. One or more shelves erected in the middle of each group of desks will be convenient, not only for holding reagents, but as places of attachment for horizontal filter supports, iron rings, etc. If every group of four desks is equipped with a funnel hood similar to that of the lecture room, there will be no necessity for ventilating chambers at the side of the room, where hydrogen sulfid and acid fumes may escape.

### *Physical laboratory*

In the ideal laboratory, either physical or chemical, each pupil has a desk supplied with all the apparatus and articles needed for the entire course of experiments, and he is not obliged to shift from one desk to another as he progresses. The cost of equipping such a laboratory is usually so great that the next best thing is taken, and that is to have one portion of the room equipped with water, etc. for experiments in hydrostatics and hydrokinetics, another portion of the room equipped with gas, etc. for heat, and another, with street and battery wires, for electricity. If individual desks are made when the laboratory is constructed, they may gradually, from year to year, be supplied with apparatus. The desks for electrical experiments should be made without any iron in their structure. Battery and other wires may be laid under the floor, and some of the batteries be kept in the cellar. It is hardly probable that when first installed, any laboratory will have more than one complete set of apparatus for each experiment. This one set will answer for a class of even 30 pupils, if the pupils are judicially shifted from one experiment to another till each has performed all the experiments.

The desk top should be at least 1½" thick, and should project over the sides and end three or more inches. Two drawers and two lockers with shelves, will be sufficient for the apparatus of each pupil. Sliding writing boards, just under the desk top and over the drawers, will be found convenient in many ways. Vertical rods with horizontal clamps, rods and rings, for supporting pulleys, pendulums, etc., may be secured to the table top by sockets. Much will be gained if the desks are in single banks, and face in one direction. There will be then less distraction to both the pupils and teacher. As in the chemical laboratory, there should be a case for the notebooks near the door.

Framed tables of densities, resistances, boiling points, specific heats, etc. will be useful decorations for the walls, though it would be more attractive to have portraits of eminent scientific men and pictures of some of the achievements of science in their stead. Opaque shades, running in grooves by the window stops, will be useful in experiments in light.

### *Preparation room*

Every progressive teacher needs, besides a lecture room and laboratories, a private room which will be at once a place in which he can, after hours, undisturbed, follow out discoveries in science, a workshop for the making and repairing of apparatus, and a place for the preparation of lecture table experiments, from which a table on rollers may carry apparatus ready set up to the lecture room. The work table should be equipped with tools, such as tinner's shears, paper cutting shears, hammer, screwdriver, wire cutting pliers, a small plane, hand drills and files. A foot-bellows and a blast-lamp for heating glass tubing, a soldering outfit, a vice and a small anvil should be permanently located on this table. It should also be supplied with mucilage, glue, twine, screws, nails, shellac, asphalt paint, binding posts, and similar articles much needed and often overlooked when purchase lists are made. Maps, models and diagrams, and the chemical balance may be kept in this room. The spools of wire may be conveniently hung on pegs fastened to a post, case or wall.

A draining table, with a grooved, paraffined top, slanting into the sink, will be found useful in the washing and drying of glassware. Hot water should be at hand in the vicinity of the sink.

In this room a card catalogue of all apparatus and stock and a keyboard, containing numbered keys to all the desks, lockers, drawers and doors, may be kept. A telephone to the janitor will be convenient. Electrical connections for the teacher's experiments in electro-chemistry, Röntgen rays, wireless telegraphy and the newer lines of research, should be provided.

### *Apparatus*

The science teacher is not hired as the school carpenter, tinsmith, or gas fitter, and should no more be expected to make all of the apparatus he uses than to print the textbooks. Let the teacher devise apparatus, make working drawings and direct in the construction. That is enough. It will be cheaper and better for the board of education to employ one good "all round" mechanic, who is a wood worker, a metal worker and a genius combined, to make the apparatus under the direction of the teacher, than to invest in so much of the catchpenny rubbish of the dealers.

Any intelligent workman can make a grooved inclined plane out of wood measuring 16' x 2" x 4", and supply it with a steel ball, stop and second' pendulum, for less than $5, which will give more satisfactory results in the hands of the pupils in the physical laboratory than a $50 Atwood's machine. Let this "all round" mechanic make levers, triangular prisms for fulcrums, center of gravity wheels, cylinders, spheres, test-tube racks, filter stands, etc.

Very good directions for the construction of apparatus are given in the appendixes of most laboratory manuals.

There is very little everyday use in a secondary school for a $100 chemical balance. The money might be invested better. Instruments of extreme precision are luxuries that few such schools can afford. Let there be an abundance of the regular working tools of the teacher and pupil, and fewer of the costly, showy pieces for the work in chemistry and physics. A good air pump and an electric machine are necessary for lecture demonstrations. Thermometers weights and scales, batteries, hydrometers, calipers, lenses and other standard articles must, of course, be purchased, *and the best is none too good for the secondary school.* Cheap, poorly constructed apparatus even when new gives but the faintest approximation to accurate results, soon gets out of order, goes to pieces, will not work, and becomes the most expensive in the end. Durable apparatus, simple in construction, will prove the best investment. Unless it is simple in construction and operation, the pupil will confuse essentials with accidentals, and either get lost in an intellectual fog, or make inconsequent inductions.

An excellent list of articles and apparatus to be used by the teacher in the lecture room, and to be furnished to each pupil in the laboratory, will be found in the standard texts and laboratory manuals. Much valuable information is contained in the catalogues of the apparatus dealers, which are furnished on application.

I venture to append a list of dealers.

### Dealers in apparatus

Alfred G. Robbins Co. 149-59 E. Huron st. Chicago Ill.

Bausch & Lomb optical co. Rochester N. Y.

Biddle, James, Drexel building, Philadelphia Pa.

Carlisle & Finch Co. 828 W. 6th st. Cincinnati O.

Central school supply house, Wabash av. Chicago Ill.

Chicago laboratory supply & scale co. 39 W. Randolph st. Chicago Ill.

Crowell apparatus co. Indianapolis Ind.

Eberbach drug & chemical co. Ann Arbor Mich.

Eimer & Amend, New York (apparatus and chemicals)

Elbridge electrical mf'g co. Elbridge N. Y.

Franklin educational co. Boston Mass.

Gaertner, William, & Co., 152 & 154 56th st. Chicago Ill.

Green, Henry J., 1191 Bedford st. Brooklyn N. Y.

Henry Heil chemical co. 208-12 S. 4th st. St Louis Mo.

J. S. Cheyney optical co. (limited) 649 N. 44th st. Philadelphia Pa.
Kny-Scheerer Co. 17 Park place, New York
L. E. Knott apparatus co. 14 Ashburton place, Boston, Mass.
Queen & Co. 1010 Chestnut st., Philadelphia Pa.
Richards & Co. (limited) 30 E. 18th st. New York
Ritchie, E. S. & Son, Brookline Mass.
Stanley & Patterson, 32–34 Frankfort st., New York
Willyoung, Elmer G. & Co. Philadelphia Pa.
Ziegler electric co. Boston, Mass.

The golden age for secondary school laboratories is certainly before us. There is a decided improvement of conditions wherever new school buildings are erected, and, wherever new laboratories have been equipped, they have put to shame those of many a college. The secondary school teachers are full of ideas ready for expression in new laboratories when opportunity arises. Keeping everlastingly at it will win success in the matter of equipment as in other things, and success will repay us for all our efforts. The surest way not to fail in getting a better laboratory is to determine to succeed.

The science department, its lecture room and its laboratories should be pleasant and attractive. The activities of the pupil are largely influenced by his surroundings. There is an intimacy between environment and conduct, and character is the outgrowth of conduct. A dirty, poorly lighted, inconvenient room, though designated as a laboratory, containing broken apparatus and dilapidated furniture, breeds slovenliness, disorder and degradation. Bright, cheerful rooms, kept neat and tidy, supplied with good apparatus and inspiring pictures, will be a powerful aid toward the formation of high ideals and the arousing of noble aspirations.[1]

A school that ranks among the best in the state (Did you ever know one that did not, according to local authorities?) may have no adequate provision for proper instruction in science.

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[1] Nowhere in the school does the quality of a janitor become so prominent as in the laboratory. An ignorant, careless one is a nuisance. A willing, intelligent one is a great comfort.

The science teachers of such institutions are truly heroic. What a howl would go up from the teacher of mathematics if chalk were furnished, but no blackboard! Would he direct the class to draw on the walls and wainscoting? What a vocabulary would the English teacher soon develop if no reference books were provided! Why should not the science department have its necessary equipment? Why, indeed, should not the science department be the first equipped and the best equipped, since the citizens who support the school usually have a conviction that science is not only a valuable, practical study, but that it is slighted in the curriculum? Furthermore, the regents stand ready to duplicate all moneys appropriated for apparatus by the local board. Again, why not? Largely, because the principal and the science teacher do not fully realize the distinctive educational value of science, and make suitable requisition on the local board for the necessary appropriation.

Confucius said: "If a man takes no thought about what is distant, he will find sorrow near at hand." Therein lies our duty as science teachers. Most of the old line academies were well equipped for their time. The modern high school, the lineal descendant of the old line academy, has inherited all of its red and green apparatus, and has for the most part added little to its inheritance.

Let us realize our position, and do what we can to better the science teaching of this state, knowing that a laboratory properly arranged and equipped will relieve the teacher of many petty annoyances arising from wrongly directed effort; that it will tend to make the work thorough, and save time and energy of teacher and pupil; that it will prevent much of the discouragement that follows failure; and that it will give the pupil a realization of the accuracy and the immutability of the laws of science which can not be gained in any other way.

This paper was illustrated with more than 40 photographs, drawings and laboratory plans.

## Management of laboratory classes in chemistry

BY PROF. A. L. AREY, ROCHESTER HIGH SCHOOL

I have no theories to offer, only a few practical ideas concerning the management of laboratory classes, and, if they are of use to any one, I shall be very glad. If they are not of use and better methods are presented, I shall still be very glad, for then I shall gain something.

I should emphasize the following points in beginning a course in laboratory work. First, I should make each pupil realize clearly that he is responsible for all the apparatus placed in his hands; that he is responsible for the care of the apparatus at all times. In order to make a strong impression on the students, I introduced a year or so ago a form of receipt, which each student signs for all the apparatus that is issued to him. I do not know that the form is the best to be had, but students will think once or twice before applying for apparatus when they have to sign a receipt for it.

This receipt reads:

*Receipt for apparatus*

Rochester, N. Y.

Having received the following apparatus in good order, I hereby promise to return it in the same good order on or before the day of examination on the term's work, or to pay the retail price for the same.

Then follow the list, the signature of the pupil and the number of the laboratory desk. After obtaining these receipts from the pupils for the first set of apparatus, they are informed that they can have any apparatus that we have in the laboratory for their experiments if they will give a receipt for it. In this way the individuality of the pupils in performing experiments is allowed full sway. They can draw as elaborate pieces as they choose, or they can perform experiments with simple apparatus if they prefer, provided they perform the experiments designated. At the close of the term these receipts are returned to the students and the apparatus is checked off. If a student returns all that he has drawn, no charge whatever is made for its use, but it must be returned in perfect order; no cracked apparatus will be accepted. If apparatus is missing, whether it is due to the student's carelessness in leaving it on his desk and giving somebody an opportunity of appropriating it, or to the destruction of the apparatus, he is obliged to pay for it; and I want to say that from the fund obtained in this way this year I obtained a fine chemical balance, such as our chairman has told us we do not need.

It is my belief that it is wise to give the student in chemistry a complete set of apparatus at the outset; that is, a set of apparatus that will last through all or nearly all of the experiments. This can be done without overloading the lockers and the drawers. The experiments in chemistry are so simple and the apparatus required for one experiment is so nearly like that required for another that the same bottles and the same flasks and tubes may be used for all or nearly all of them.

A second point which I should emphasize at the outset is the necessity for cleanliness with the apparatus. I should give students the reasons why it is necessary that the apparatus be kept clean, and show them that the presence of chemicals on the sides of their tubes may interfere with the success of their experiment; that the presence of chemicals in their delivery tubes may clog the tube by forming a precipitate. It is a convenient thing for the teacher to have in his vest pocket a little notebook with the name of each student in the class, so that, when he finds apparatus which is not in good order, or when he notes any point in the work of a student that gives him an idea of the character of the work that that student is doing or that needs correction, he can make an entry after the name of the student. I find that students, seeing the notebook come out of my pocket, are very anxious to know why a note is being made; that they are very anxious to find out what is wrong with their apparatus and equally anxious to correct it. I have made it a point to impress on the students that if glassware looks like cut glass it is clean and to give them that as the ideal.

A third point that I wish to impress on my students at the outset is that the notes are to be taken as the experiment proceeds and in as perfect form as possible; that they are not to be left for some subsequent leisure period; that they are not to be taken on bits of paper, but are to be taken and completed during the laboratory period. For a time it is necessary to devote considerable attention to the character of these notes; and I find it a convenient method to have the notes of one day's experiment read before the class and criticized by the class and by the teacher at the next day's recitation. It is desirable also to give them models, calling attention to good models that may have been presented by members of the class. If none are satisfactory, I write notes of the experiment that they have just performed, that they may know what is good in the matter of note-taking and what is bad. Later in the course I abandon this reading of notes in the class to a certain extent and rely more in the recitation on the logic of the experiment, on the argument that the student has gone through with in conducting the experiment and on the facts he has acquired from his observations. This is in addition to the proper correction of the notebooks at stated intervals.

During laboratory work the teacher's presence is quite important. The teacher should remain in the laboratory as long as the students are experimenting, he should not be in his private room, he should not be expected to dispense apparatus. New apparatus that is required by the pupils or broken apparatus that needs to be replaced should be issued by a dispensing clerk. The teacher should know when the class goes into the laboratory that every student in the class understands the object of the experiment before him, the general method of the experiment and the kind of apparatus to be used. Very often teachers maintain that no preparation for laboratory work is necessary, but I think it would be better to require this amount of preparation. I would make sure that each student had that information by questioning before the work commenced. The teacher should at the beginning of each laboratory period state clearly the precautions, if any, that need to be taken, and should explain to the students why these precautions are necessary. I believe that the accidents, the explosions and the burns that occur in the chemical laboratory are due to the failure of the students to understand the truth. I have in some 18 years of experience in the chemical laboratory had two explosions of hydrogen flasks. They were both due, however, to the personal equation of the individual and not to the fact that he did not understand that what he did might cause an explosion. If the class is to use concentrated sulfuric acid, I see that every one in the class knows that that substance is dangerous to handle and must be handled with care; that, in case any of it comes in contact with the clothing or the hand, it may be corrected by the immediate use of an abundance of water and that a burn may be prevented if a paste of sodium carbonate is placed on the spot within 15 or 20 minutes. I would also have them understand that phosphorus is not a safe substance to handle, that phosphorus should be cut under water, that it is unsafe to hold it in your hand, or even to pick it up. Phosphorus is a treacherous substance. There is the new phosphorus that looks almost like crude paraffin and is quite different in the facility with which it takes fire from that which has been in the laboratory bottles for some time and has become transparent. I would also caution students when an explosive gas is prepared, a gas that is explosive when mixed with air. Let them clearly understand what causes the explosion, and, if they understand that, I assure you that they will not willingly touch a match to an explosive mixture. If hydrofluoric acid is to be handled, students should be cautioned concerning it. Familiarity with acids often leads to carelessness. I have known students to put their hands right into hydrofluoric acid; and have known students to lose all the fingernails of one hand as a result of that experiment. It is not always possible to make a statement of the facts which will produce the effect that is desired, but it is a very easy matter to collect stories of accidents that have occurred in almost any of the experiments; and, if you have a particularly bad class, I should tell a particularly frightful story of an accident. Impress on them the importance of being careful in handling these things.

At the beginning of the experiment the teacher's notebook should be in frequent service. The teacher should note errors in the experiments. He should make a certain note to indicate a loiterer, another to indicate a careless or clumsy experimenter, and should at all times be ready to ask the student why he is doing such and such a thing.

I note that the new syllabus in chemistry makes no mention of qualitative analysis. Personally I believe that this is an important topic, that it has considerable educational value, and I am very glad to note that our new syllabus is brief enough to allow time for this work. Much labor will be saved if the unknowns that are to be analyzed by the student are all given out at one time. I have had little boxes made in which are 10 smaller boxes. Two or three of the larger boxes can be given to the student — as many as the teacher thinks he can work out during his course. It is my practice to give 25 unknowns.

It is worth while, I think, to have printed forms for reports. I have used this form for several years and the students are much more careful in their work than they are when they have simply to go to the instructor and ask if their unknown substance is such and such a thing. After a student has finished three substances I allow him to hand in a report.

Then there is the statement of the instructor in the laboratory giving the date that the report was received. This gives us a complete record of the student's work. When he wishes to correct his report a supplementary report is handed in, but he is never allowed to hand in more than five reports on one box.

**Prof. G. M. Turner** — I would like to ask Prof. Arey, or any one else who may happen to teach chemistry, if he knows of any good method of correcting notebooks — something which does not involve the laborious task of going through each and every one.

**Prof. W. A. Brownell** — I have used this method. My pupils come in with their books and I have them change books, so that each will have a little pride from the fact that he knows others will see his notebook. Then I call on some one to rise and read the notes in the book which he holds, and the pupil that reads is not bashful, because it is not his own book. Then, if any one in the room disagrees with anything in the notes, hands will be raised, and often there are a dozen hands raised, after which I call on one to state his criticism. Perhaps the thing criticized is right and the critic is wrong; if so, some one will criticize the critic, and in that way you will get a fine discussion of these notes during the class hour. You need not give your opinion. Let pupils make their mistakes, and their interchange of thought will bring out a large amount of information for them as well as save much hard work for you. Then correct the notes, and you will find that two thirds are all right. Henceforth the task of correcting the notebooks will be easy. When you are dealing with 150 pupils, such shortening of time as that is important. That is one scheme that I have devised for the reading of notebooks. I think it would be a sad thing if the teacher were compelled to read so many papers at night that he went to his room exhausted and next day did poor work because of his weariness. The interests of both teacher and pupils will be enhanced by maintaining the elasticity of the instructor, and whatever contributes to this result should be hailed as a benefaction.

**Prof. E. R. Whitney** — I would like to make one statement in regard to the chemical balance. I do not wish to be understood as not in favor of extreme accuracy in the laboratory, for I am. In too many schools the total equipment consists of a chemical balance, a very fine electric machine and a good Atwood's machine. If that same money were distributed in a different way, it would give better results. The greater number of these instruments of precision we have the better, of course. Let us, first of all, get our laboratories equipped with the more common and useful working tools. By the use of these, the pupil becomes so trained that better results will be obtained by him from the chemical balance and the Atwood's machine.

**Prof. I. P. Bishop** — Perhaps my experience with notebooks may be of interest. When we first began laboratory work, we used a book with printed heads; but, finding that students had a tendency to record their work in a mechanical way, I abandoned it for a blank book large enough to hold the work of a term. The left hand page is kept for scratch work, the permanent notes are recorded in ink on the right. Each experiment is written up in the laboratory before the next is begun. In physics the books are inspected before the pupils leave the room. In chemistry, where the notes are more voluminous, the books are read as often as once a week. As we have at all times from 125 to 175 pupils in the two subjects, the task of reading the notes is very burdensome. During the first two or three years it nearly killed me. Now, when a class begins laboratory work, I indicate in a general way the form in which I wish the notes recorded. On the morning after the first laboratory period I have the notes read and criticized in class. This reading and criticism are kept up for a week or two, till the pupils understand what is required. Then each day as many notebooks as we can take care of are called in, read, corrected in red ink and returned to the pupils for revision. For a time I availed myself of the aid of members of the class. Taking a group of six or eight of the brighter students, I read with them several books, calling attention to the errors and necessary criticisms. Then they continued the work by themselves. In that way I saved myself about two thirds of the labor. Now I have turned this work over almost entirely to my assistant, who gets some help also from pupils.

Another matter that I consider of the greatest importance, specially in chemical laboratory work, is that the pupils shall always work under supervision. Unless the work is analysis, the presence of the teacher not only adds to the quality of the work but to the element of safety as well. We draft into the service as assistants the graduates of previous classes and in that way give them valuable drill in handling pupils. Manipulations are carefully watched and as a consequence, in 11 years we have had no accident more serious than burned fingers. As our work is, in large part, the training of teachers, this utilization of pupils for reading notes and assisting in the laboratory is not only legitimate but almost a necessary element of their education.

**Prof. W. M. Bennett** — We sometimes do a deal of unnecessary work. While it is frequently said that the science teacher should see to it scrupulously that these notebooks contain good English, perfect spelling and pretty good penmanship, I hardly think it is right to require of the science teacher any very careful examination of the notebooks in this respect, unless we hold the teacher of English responsible for accurate statements in science. We have a great many notebooks in both chemistry and physics to look over, and though we have assistants, it seems to me a little wicked to ask them to do the work alone. I have found that in correcting notes it is unnecessary to go through all the written description and all the observation leading up to the inference of the pupil. Frequently a teacher may devise a chart arrangement of an experiment which he may place before the pupils and have them follow, and, in looking over these charts, the teacher can see almost at a glance whether the results are what they should be. It is a great labor-saving device with me.

**Prof. William Hallock** — This touches a hobby of mine, the material that is to go into the notebook. Much of the work in taking care of notebooks lies right there, and the main difficulty is teaching the pupil to get down in the notebook in as concise a manner as possible all that is absolutely necessary and nothing else. I think that many notebooks, particularly laboratory notebooks, contain an unnecessary amount of descriptive material. I know this is so in physics from the notebooks presented for the laboratory requirements. It is not necessary for the student, when he has gotten along a little way, to go into the details and make a lengthy report. When you get the essentials, with a glance you decide on the notebooks, in the first place whether the result is right or not; and, if the result is wrong, you follow back and see where the error is. If the result is right, the presumption is that the work is right, and one or two points in the process will tell you quickly whether or not it is correct.

I am glad to see the unanimity in the opinion that notebooks should be kept primarily in final form and not as memorandums to be written up subsequently, and also in the suggestion that the actual record should be kept on one side and the memorandums on the other, because often the memorandums give the teacher the real clue as to where a difficulty is.

**Prof. W. J. Hancock** — I am troubled by this notebook question too. I believe in the use of illustrations, wherever possible, in place of long descriptions. For instance, take the preparation of hydrogen. A drawing representing an ordinary flask with thistle tube and delivery tube, zinc and water in the flask, a bottle of sulfuric acid held above the thistle tube, and hydrogen coming from the delivery tube, conveys the idea as well as a two page description. You can look at an illustration and see in an instant what the pupil has done.

A word or two about explosions. I believe in explosions. I believe that, specially for beginners, it is a good plan for the teacher to cause one or two right sharp explosions to take place under conditions such that no one can be injured. This has a better influence in teaching the class the necessity of using care when handling chemicals than almost anything else you can do.

## Management of laboratory classes in physics

BY PROF. FRANK ROLLINS, BOYS HIGH SCHOOL NEW YORK

If the brief statements of this limited discussion seem dogmatic, it must be remembered that my time permits only the shortest expression of opinion without any accompanying reasons. It is to be expected and desired that later discussion will exact severe penalties for any misjudgment of mine.

Our topic may fairly be interpreted to mean the complete management of a laboratory class in all the work which it attempts in physics, and includes lecture table demonstrations, study of textbooks, collateral reading, quizzing and examining, as well as manipulation of apparatus in the laboratory.

The great value of laboratory work has often led to the abuse of laboratory methods. Laboratory investigations are sometimes pursued as if they were ends in themselves rather than means for arriving at desirable ends. The present tendency among the best teachers is probably somewhat away from extreme emphasis on the amount of individual laboratory work. On the average not more than one third of actual classroom time should be spent at the laboratory tables, and the exercises performed there should be serious, worthy investigations, for the most part involving careful measurements of the significant conditions. Even such facts as used to be valued for their qualitative significance are better understood and better remembered, if they are scrutinized carefully for quantitative determinations.

Each recorded exercise should begin with a title stating concisely the purpose for which the investigation is made. (*See* exercise appended on temperature and pressure of steam, for general form of exercise and nature of conclusions.) A *truthful* (though not necessarily artistic) drawing of the apparatus should be made, showing conditions as they are at the most suggestive part of the experiment. A brief description should supplement the drawing, if necessary, but should never be lugged into the record for the sake of obeying some fixed rule of procedure. All numerical data should be recorded in neat and expressive tabulations.

Special difficulties, peculiarities, or variations of the exercise should be noted.

Thus far all notes should be made in the laboratory with the apparatus *actually in use* before the pupil. Reflection on the meaning of the exercise, calculations based on numerical data, and formulation of conclusions may well be left for deliberate home study. Every exercise should end with a clear statement of the main conclusion arrived at, together with any secondary conclusions which may justly follow; and the logical necessity, which compels these conclusions from the data and the reasoning, should be as clearly demonstrated as in any exercise in geometry, though of course the conclusions in a physical science may never be asserted with the same universality as in pure mathematics.

To secure such work as I have described, the teacher must be at the pupil's elbow in the laboratory, specially during the first exercises, and must direct his thought by skilful questioning or, if need be, by minute and specific direction. There is no great harm in telling a pupil something once in a while, provided one knows when to stop telling.

Notebooks must be read closely and carefully just as soon as the exercise is finished, and at first even before the exercise is finished. Teachers who wait for the Thanksgiving recess or Christmas vacation to read up stacks of notebooks, heap up for themselves unnecessary troubles by permitting pupils to go on making mistakes which never should have occurred after the first exercise. Much helpful criticism may be given to the pupil, as he works in the laboratory; but every book should be thoroughly inspected at least as often as a new exercise is done, and brief criticisms on slips of paper, numbered to correspond to the numbers of exercises, should be left in the book, to be removed by the teacher only, when suggested corrections have been made. Such criticisms may consist of brief expressions such as "Spelling," "English," "Intermediate results not named," "Names?" "Conclusion not true," "Conclusion indefinite." If the slips of paper used on a given afternoon are struck with a dating stamp, corrections are likely to be made more promptly. If later inspection shows corrections neglected, a new date struck on the slip may serve as a request for immediate attention. When all corrections have been made, an exercise should be stamped "Approved," "Accepted" or "Not approved," as it may deserve, and the teacher should check off the exercise on his list, to show that it has been disposed of.

The actual laboratory work of the pupil should be the foundation on which and about which all his study of the subject should be built; but it is impossible to give time enough in the secondary school for a comprehensive study of physics on the individual laboratory plan alone. Many qualitative experiments should, therefore, be performed by the teacher before the class, by way of preliminary demonstration in a given topic, or as the basis of a quiz. Such demonstrations should also be used with great frequency and in great variety to link everyday experiences and phenomena to the principles of physics immediately under discussion.

The principles of laboratory exercises should be fixed by applying them to numerous, varied mathematical problems, so planned that first one and then another factor shall appear as the unknown value to be determined. If algebra has been taught to the class before physics (and it always should be taught before high school physics), the equation should be applied constantly to the only purpose for which it was invented, or for which it ever ought to be learned, viz, as an efficient tool for scientific investigation. Save time, arrest attention, and compel pupils to attend to home lessons assigned by having frequent, 5 minute written recitations, allowing one minute each to about five clear-cut questions, each of which may be answered in a minute's time and in the space of two lines. Then hold a brisk oral quiz on the same topics, after you have taken up the written papers, while interest in those questions is keen. Such short written tests serve as a very fair basis for daily marking, and they are considered very important by the pupil, if it is known that they are so used. Hence they offer a special inducement for every pupil to prepare every lesson every day.

The historical and descriptive literature of physics should be studied, not only from one good textbook, but from a good department library as well. It is not enough to know that there is such a law as that of Archimedes; it is well to know something of Archimedes himself, and that he did some other things quite as creditable as dozing over a problem in physics, while taking a bath. The personality of a Dalton, a Faraday, or a Maxwell is quite as inspiring as a dry statement of the mere results of his investigations. If the necessary books are given to pupils with references to chapter and page, they like to look up the heroes of their study and make reports to the class. This sort of work may be so distributed as not to prove burdensome to anyone.

If a mad scramble after quantity and variety of laboratory work, or a consuming desire to drill a class up for examinations in precise definitions, or in curious and striking mathematical gymnastics, shall ever prevent us from making our pupils feel the *human* interest of physics in the past, and share the interest of the present; if we shall fail to make our boys and girls conscious, as they are of their personal existence, that the laws of physics are the laws of the universe, from grain of dust to blazing star, then we shall have failed to make physics worth studying at all, and we ought to be in some other occupation.

But I perceive that you ask, " Where is all the time to come from for the varied work you have suggested ? " My answer is that your scientific training, both in your preparation and in your professional work, ought to enable you to economize time and all the forces of your department as no other teachers can; and again we must so teach physics that the responsible makers of courses of study and of school programs can not afford to deny our subject its proper amount of time.

The teachers of classics have been able to dominate school programs, not because of the intrinsic educational value of their subjects, but because of the masterful use which they have made of much poorer material than physics.

History, English and mathematics have obtained most generous allowances of time, which no science man begrudges them. Greek is settling our old contention, so far as it is concerned, by slowly retiring from the field, but why should Latin receive five and six hours a week during from four to six years before the pupil goes to college, while physics is limited to three or four prepared lessons a week for one year? Some of the best Latin teachers in the state tell me that they have abundant time to prepare boys in all the Latin required to enter Harvard or Yale, before the middle of senior year, and that they "fill in the time" for the rest of the year in reading Ovid or Livy or some other Latin which their pupils will take up in college freshman year. Small wonder, indeed, that Latin teachers have a reputation for giving boys an excellent preparation for college; and, still better, a reputation for giving boys power to do college work successfully. What might we not make of physics, as a means of discipline and culture, with half the time now bestowed on Latin!

It avails nothing to rave against Latin as a time-consuming monster, however well it may deserve that name. The teachers of Latin are in possession of a lion's share of all high school time. They are backed by superintendents and principals whose training was largely classical; and what better recommendation can any man have for any course of training than that it was the course which produced *him?*

In all the cunning arts of argument and persuasion, our classical rivals are more than a match for us, and our appeal for more time and larger opportunity must be made neither to official sympathy nor to argument, but rather to the intelligent self-interest of our official superiors. We may expect no concessions which we do not compel by teaching physics so well that the physics class will become the most popular in school; that men with common sense will demand for their sons and daughters larger opportunities for studying this eminently practical science; and superintendents and principals will discover that the physical laboratory can not be shoved off into any old garret or cellar, that five periods a week, with an extra period joined to one of them for laboratory work, is no more than a fair allowance of time, and that a subject of so great importance should not be assigned to a lower position in the course than junior year for general courses, or senior year for college preparatory courses.

My final word, then, concerning the management of laboratory classes is: Let us go home; stop talking about grievances in the matter of time and opportunity; teach physics as we never taught before; organize with our colleagues in neighboring towns for improving methods and devices; visit, consult, correspond; and again and above all TEACH, till we place physics, where it belongs, at the head of subjects which combine discipline with practical culture.

# EXERCISE

ON

## TEMPERATURE OF STEAM AS AFFECTED BY PRESSURE

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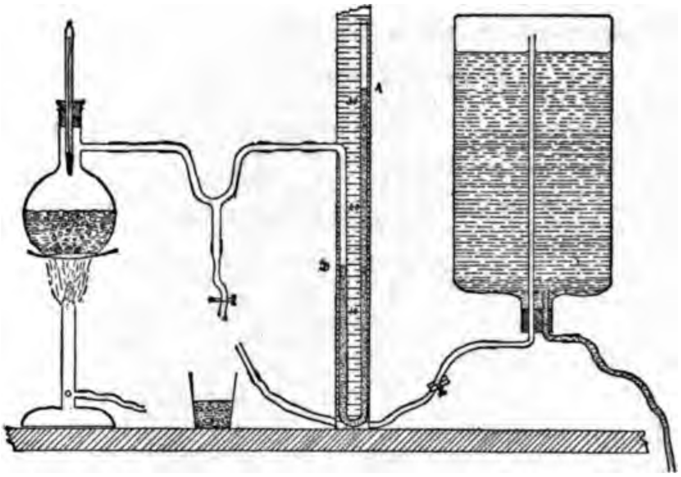
*Exercise prepared and apparatus devised*

BY

FRANK ROLLINS, Boys high school 60 W. 13th st., New York



***To see if there is any relation between the temperature of steam and the pressure to which it is subjected.***

***Apparatus:*** **1 Distilling flask with rubber stopper, 1 thermometer, 1 glass Y tube, 1 pinch-cock, 1 screw clamp, 1 manometer tube (20 cm from bend to top of long arm), 1 (6 lb) acid bottle, right angles and connectors as shown in drawing. Small pieces of brick should be put into the flask to prevent "bumping."**

***After*** **the open manometer has been read, the aspirator should be connected, and the temperature under lowest pressure should be noted first. When the pressure is higher than normal, the aspirator should be detached, and the escape of steam should be prevented by the pinchcock. Below is the first part of a sample tabulation.**

**No. of thermometer..................................**
**Barometer reading..................................**
**Manometer, arms A and B open...................**

| **TEMPERATURES** | **MANOMETER ARM A** |
|---|---|
| **95°** | **219 m m** |
| **96°** | **235 m m** |
| **97°** | **etc.** |

**On cross section paper, starting from any convenient point, lay off vertical distances to represent rise or fall of temperature from that indicated in free steam. Lay off horizontal distances to represent increase or decrease of pressure from natural pressure of the atmosphere. Draw a curve through the points thus located by co-ordinates. From your completed plot, answer the following questions:**

**1 Is there any definite relation between the temperature of steam and the pressure to which it is subjected?**

**2 What increment of pressure on the average corresponds to a rise of one degree in temperature?**

**3 What would be the reading of your thermometer in steam under pressure of 760 m m?**

**4 What is the boiling point error of your thermometer?**

**5 Under what pressure would steam cause your thermometer to read 10° higher than your highest reading?**

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## Section C — EARTH SCIENCE

### Management of laboratory classes in earth science

BY PROF. W. H. SNYDER, WORCESTER (MASS.) ACADEMY

I simply brought a few pieces of apparatus from our laboratory to show what we are trying to do. Those who took the little pamphlets I laid on the table this morning know what the course is as we develop it.

The first thing we do is to illustrate the shape of the earth by the little drawing which you will see here. (Exhibited) The inside of the circle represents the shape of the earth. The outside is a true circle. You see that it would be impossible to distinguish with the eye the difference between the shape of the earth and a true sphere. Then, you will notice, there is a name written. Just under that name is a point which is $\frac{3}{10}$ of a millimeter high. That represents the hight of Mt Everest.

For a boy to understand geography, he must have an idea of distance. For convenience, I begin with the distance from Worcester to Boston, a distance familiar to the boys. Then lines are measured off representing the distance from Worcester to Boston, to New York, to Chicago, to San Francisco and to Manila, for the boys are just now interested in this place, and finally the circumference of the earth. The distance from Boston to Worcester as a standard is taken and the other distances are measured in terms of this standard.

The next exercise is somewhat of the same pattern and is to given an idea of areas. This plan was made by a boy. It is neither the worst, nor the best. One of those little squares represents the area of Massachusetts, then the area of the United States, area of Canada, etc. The next step is to write the population in each. He finds out that Massachusetts has a population of 2,000,000, etc. In this way he gets an idea of the area of different surfaces, and sees that population does not depend entirely on area.

The work on areas is followed by the study of flat surface maps. First I send the boys out and tell them to draw a map of the campus and put it on a flat surface. Here are some of their maps. I have them pace out the distance, and construct maps accordingly. My object is to give them an idea of distance and then how a flat map is made.

The first thing I did was to take a contour map of Mt Shasta. I told the boys to get the width of it. They allowed so many squares to represent a mile horizontally and 10 times as many to represent the same distance vertically. Thus they constructed a rough cross section. I told them to go out on top of a hill near by and draw a cross section of the country. Here is the result. (Exhibited) It is pretty hard to draw a map. I had them draw a cross section of the Connecticut river valley. The city of Springfield lies on this flood plane.

The next thing is to draw a contour map. I happened to be in Cambridge a year ago last summer when Prof. Davis had several imperfect models which he did not care for any longer. He gave them to me and I had them sawed into pieces like this.

Now, as I said this morning, there is one thing that the laboratory ought to teach the boys and that is to rely on themselves. I simply carried these models into the laboratory and gave the boys a few points about a contour map, the hights, etc. and set them to work. Some of them thought they could not make a contour map and others thought they could. They all had to try. Here are the results of their work. (Exhibited)

After these exercises, which require three or four periods, I take up general map projections. First, they build a flat surface, then a cross section of a contour map. Our next attempt is to make the projections of the surface of the earth. I have a little scheme for that of which I am proud. I gave to each fellow a little globe, a piece of paper, some thread and a pair of compasses. All I told them was to make a map of North America as shown on the globe. If a boy does not study out his schemes, he will not do much. When each had completed his map, I told him to trace it on a piece of tracing paper and then fold it back on the globe. He did so but North America did not come just right. When the drawing hit in one place, it was away off everywhere else. Some were too big all the way around, and the boys concluded that they did not know how to do it. That was just what I wanted them to know. They could not make a flat surface map from a curved surface globe. This is a model that shows the orthographic projections. I have drawn the circles on this globe, and the poles, tropics, etc. Now project them straight out and you will get a projection similar to the one I have here. I told them how to make this projection. Here are the results. (Exhibited)

Then I gave them these sheets showing the longitudes and latitudes of different places. They plotted the points and drew in the outline. They found it outlined Australia. In this way the boy gets an idea of orthographic projection.

Here is a model illustrating the stereographic projection. In a stereographic projection, a man stands at one side of the earth and looks at a tangent plane on the other side. Now you can see, and a boy can see, that all these views focus at a point. On this globe is drawn the parallel of capricorn and of cancer, poles, etc. You put that on a flat piece of paper and you get what I have here, an exact reproduction of a stereographic projection. Here is a map of that projection made by a boy last year, exactly as he gave it to me.

I next take the conic projection. The orthographic projection is not exact, except at the equator. No projection gives all places exactly right. In this particular case the paper is folded in conic shape, tangent at 15°. Here is the method of projection and here is the map of North America. Next, Mercator's projection is considered. By this time I think they understand these projections fairly well.

Now, I want them to get a good idea of a watershed. I gave them a map near our own place; and it happens that some of the streams run north and some south. It is a good exercise because they have a distinct watershed line at this place. You can see from the samples how clearly they can determine the line.

This is a little device for explaining about the sunlight on the earth. Keep the north pole in the right place. Boys are liable to have the north pole in every direction. They must carry it parallel with the lines and then they will learn to understand it.

After that we use a great many contour maps. These can be purchased of the government at 2c a sheet. My idea is that, if the boys are going to understand physical geography, they must get in the secondary schools the ground work that will enable them to go on with the subject. They must know the surface of the earth as they see it, and must try to understand the places they can not see. If they can not understand maps, they can not do the work.

I find pictures assist very much in geography. I have 400 or 500 pictures classified and ready for use on every occasion in the laboratory. I mounted them myself, and they cost me less than $15. One sheet of the cardboard costs 7c and makes four large mounts. I find them a great help.

Taking everything into consideration, I believe a physical geography laboratory can be equipped, and well equipped, with less expense than any other laboratory.

Of course I use charts for islands, etc. By this means pupils can readily understand the difference between continental and deep sea islands.

**Prof. C. Stuart Gager** — I can presume to offer little if anything that is new. The aim has been merely to state what laboratory exercises I have tried and found practicable, indicating, first, what the teacher's attitude should be toward the work and what object he should seek to accomplish by it. I recently heard a student describe the laboratory to another student as "a place where the pupil does all the work and the teacher doesn't have to do anything." I shall not need to point out in this presence how much of the remark is true, but for a few moments let us keep in mind this idea, that laboratory work is any work in which the pupil secures his knowledge at first hand by being brought into contact with the facts instead of depending wholly on the results of the labor of others, and the laboratory is any place indoors or out where this work is done. This work secures, not only knowledge, but a training, mental and manual, which can come only by getting knowledge in this way. It is by no means implied that the pupil shall come to disregard or depreciate the work of others, or sell his birthright to the fruits of past labors, but it is implied that he shall be emancipated from, or never be permitted to acquire, the habit of blindly following others — that he shall be fitted to become a leader, and shall acquire the power and habit of originality and independence of thought. I believe we should cease to speak of the laboratory as a method and use this term only in a stricter pedagogic sense. The laboratory is only a device for applying a method. The method is that of science, the laboratory a means to an end.

I can not distinguish between the object of the laboratory work in any course, and the object of the course in general. The object of both is to educate the pupil. This has been accomplished in proportion as the pupil at the end of the course possesses, in larger measure than before, a knowledge of important facts, and the ability rightly to interpret facts and to solve independently problems which present themselves, has acquired larger sympathies and wider appreciations, and has been brought to a completer realization of his relation to his environment.

If we correctly understand the term, observation, it will mean all that I have mentioned, and no one who understands the psychology involved will speak of exercises given "to train the faculty of observation." Observation "can never mean less than the reading of meaning into the object present to the senses, and this requires the complex activity of the whole mind — perception, memory, imagination, judgment, and reason, with feeling and volition. Not one of these can be omitted from a real act of observation."[1]

If this statement seems too broad, we may make it more specific, and enumerate the following points which the teacher should always seek to accomplish as a result of the work.

1 To arouse a spirit of inquiry and interest in geographic knowledge.

2 To develop the power and habit of geographic observation, in order that true fundamental ideas may be acquired, as much as possible at first hand.

3 To develop the scientific imagination.

4 To develop the power of inductive and of deductive reasoning.

5 To show the preparation of the earth for man, and his relation to his environment.

With these points in mind and with this attitude toward the work I have made laboratory exercises the basis of all my class discussions in physical geography. I have divided the exercises as follows:

1 Those which are to be done indoors
  *a* Those to be done at school at regular class period.
  *b* Those to be done at home or at school outside of the regular class period.
2 Field work

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[1] Prof. Arnold Tompkins, *Supplement to Herbart yearbook*, 1897, p. 147-48.

Some of the exercises are entirely completed in some one of these places, others require work in all three.

1a *Mathematical geography*

1) Explanation of change of seasons with very simple home-made apparatus
2) Map projections — specially Mercator's and conic
3) Explanation and study of contour-line relief maps

*Geography of the air*

1) The structure and use of the mercurial barometer
2) Structure and use of the vernier
3) Determination of dewpoint
4) Study of weather maps — analysis and synthesis — from furnished data
5) Written description, from maps in the *Monthly weather review*, of the distribution of rainfall in the United States. Where is it greatest? Where least? Why? Consult a map showing distribution of population in the United States. At what meridian does dense population cease rather abruptly? Compare this map with the maps showing distribution of rainfall. Can you now explain the facts of distribution of population, shown on the map? Find similar instances in other countries.
6) Distribution of precipitation in New York state, as in 5, studying maps in monthly report of the New York state weather bureau. Does any relation exist between topography and distribution of precipitation? Give facts in support of your opinion.
7) Study of isothermal maps of the United States. Illustrate by diagram the general position of the isotherms and account for it.
8) Experiment to illustrate convection currents in connection with planetary circulation.

*Geography of the ocean*

1) Comparative study of maps showing planetary winds and maps of ocean currents, with written account of the exercise and inferences as to the cause of the ocean currents

1b *Mathematical geography*

1) Determination of the local meridian

   At high noon set a watch so that it shall indicate local time.

   Compare this with local time obtained from the sun dial at the city hall.

2) Determination of the altitude of the sun on the equinoctial and solstitial dates

   Compare the results and explain the facts ascertained.

3) Find the difference between local and standard time
4) Determination of local latitude

*Geography of the air*

1) Determination of the local magnetic meridian
2) Magnetization of long iron bar by bringing it under the influence of the earth's magnetism
3) Written interpretation of isogonic charts of the United States
4) Sunshine record for several days by blue print recorder
5) Study of the paths of "highs" and "lows" across the United States. Suggest explanation for the facts. Of what economic importance are they?
6) Visit to the local weather bureau office
7) Study of variations in the area of the shadow cast by a given object, parallel to the sun's rays, at different dates
8) Observations of local temperature, pressure, wind, cloudiness and precipitation for five to 10 consecutive days, the results chartered and followed by exercises in forecasting, supplementing local personal observations with data from the weather map

*Geography of the ocean*

1) Study of tidal phenomena in the Hudson river at Albany.

I have not given any exercises on the geography of the land because most of my work in this line is outdoor work, the indoor work being largely confined to a study of maps and pictures, with the drawing of instructive profiles. My own classes are fortunate in having an opportunity to study the large relief model of New York state, and smaller models of other regions at the state museum.

I should be at a loss to know how to proceed with my classes in physiography unless I could take them into the field. I have found more objections to this work in magazine articles than in actual experience with it. With a school located in the heart of a city of some 100,000 inhabitants, I have been able to do enough field work to serve as a basis for class discussion in nearly every topic under the geography of the land, and much of this work has been done within six blocks of the school building. We are fortunate in having a large park of varied topography right across the road from the school; and there are clay cuts in the old estuarine plain along the Hudson, and exposed sections in the cross-bedded sands and gravels of the associated delta plain, which offer a fine opportunity. The underlying Hudson river shales are exposed within four blocks, and here we have a good opportunity to study soil. The effects of running water may be studied in any locality where it rains. A taste of field work of this simplest kind, and the prospect of a day's outing in the country, I have always found sufficient inducement to most of the class to take more extended trips on Saturdays.

The order followed in the field is 1) observation of facts; 2) recording the work in the form of brief notes, drawings and photographs; 3) interpretation of facts. Careful mapping and section drawing is always urged as a means to more accurate observation, as a test, showing how well the observation has been made, and as giving the pupil the best possible record of the work. The making of sketches is likely to be thought too difficult by beginners in field work, but a few illustrations of what may be shown by a few lines, disregarding any attempt at artistic effect other than neatness, demonstrate the ease of thus recording the observations.

The student is always required to do his own reasoning on the facts in the field, and to draw *some* conclusion from them. Then comparisons are made, suggestive questions asked, and the right explanation of the given land form arrived at. In this way the wet weather delta which we could stand on and measure made clear the great fossil delta from Albany to Schenectady, gullies of rain erosion threw light on larger valleys, an oxbow cut-off in the Normanskill near Albany made the map of the lower Mississippi region full of meaning, and a visit to the Helderberg escarpment at Indian Ladder made the topography of the great coastal plain of New York state a part of the actual experience of us all. The increased pleasure, and interest amounting to enthusiasm in the classroom work that follows these excursions are a sufficient reward to the teacher for the extra time required, and become to teacher and pupil alike a real inspiration.

**Prof. W. A. Brownell** — I had intended to say some things that have been said in each of these papers. They are all helpful. And I can still say some things with reference to the outdoor laboratory.

I would like to impress this, that the teacher in the large cities, in New York for instance, can do quite a little outdoor work of this character, because he does have rain and the city is not entirely covered with pavements. If it rains he can take his class to the window and show them and illustrate all this matter, and they will get almost every form of instruction.

You can do a large amount of work in comparing buildings of the cities of the state. Watertown is dominated by lime rock, Auburn and Syracuse by rock, etc. A little south of Watertown the Trenton limestone dominates. I give these as a suggestion to compare prominent buildings of the towns dominated by those rocks. Some of your pupils may have visited some of those places. You will say to a student that in such and such a section such and such rocks abound, asking what he thinks will be the composition of the prominent buildings. Now they will draw other conclusions. The inference is always the most important part. Those in cities have opportunities, for trolleys, steam-cars, etc., will enable you to go out now and then. In New York in Central park, fine opportunities for this work exist.

Our state is highly favored in physical geography. We have unusual opportunities. We have sandstones, granite, etc. and your students can see the action of acid, oxygen, frost, etc. In Europe you will find specimens of rock from Watertown. Remember that all these gorges, cascades, etc., you usually have near you. By some agency or another you have opportunities. Any phases that you have in books will be illustrated in various ways.

Farther south you have lakes, Cayuga, Seneca, etc., sunken deep into the rock, channels, etc. Excellent opportunities abound for every school in that section. Farther south you have the Chemung and Susquehanna, at Elmira, Binghamton and other places, and you have high lands and low lands with corresponding results. As I said beforehand, not a place but that renders some opportunities for this field study.

If there are any teachers in the world who will have a right to sing the doxology, it will be the teachers of physical geography in the state of New York.

**Prof. Frank Carney** — There is little left for me to say. I will not attempt to tell you who have easier facilities to work with, how we work who do not have so many accessories at hand. Recently I wrote to Mr Cornish that my remarks would be connected with Cayuga county, but even that field has been considered. I think there are possibly one or two points in which you teachers, who do more or less field work, will be interested.

Are we always well prepared to take a class into the field? I speak from experience in field work under the instructions of others, and also from work with my own class, and I have found that it is a misfortune to be taken to a field that has not been visited before by the professor or instructor. Many questions are asked that are not sufficiently answered, and many times there is evident embarrassment on the part of the teacher. So I would call your attention at this time to this as one of our possible mistakes. Never, if you can avoid it, take a class to a field that you have not first looked over.

I might state that I find it profitable to my classes to go slowly. If you can visit but one stream in an excursion, do that thoroughly. You will gain more for your classes by giving thorough consideration to a short or narrow region than by leading them rapidly from one locality to another.

In connection with each excursion I find it best to assign a separate task to each member of the class. One of the examples I might mention is this. We have in my neighborhood a number of gorges, and each time a class visits them there are new droppings of materials which have weathered away from the sides but may be hanging. A portion of a ton's weight may be about to fall. I have one student describe, developing imagination of course, the effect of another winter's weathering on that overhanging mass? Where will it go? What will become of it after it has been ground by the action of the weather? I may set another student to making, when the weather is clear, an examination of the lake shores. Where the slopes are different he will find different sized stones, in some places large, in other places smaller and even ground up fine. I avoid general work as much as possible. It is not the right training. General field work is apt to produce the habit of hasty conclusion.

Field work is largely conditioned by location. Some of us might go into details which would be impracticable for others in their locality. Each teacher has to determine the nature of his field work.

I find that reports on the results of our excursions are helpful. Say, have them once a week in class. Some student may be dull or has not given a good account of what he has studied and seen. Do not compare with better students. I often find that the student who seemed dull the first year develops into the best student at the end of three or four years, far surpassing those who made brilliant progress at the first.

It has been my purpose simply to point out a few of the snags which teachers sometimes run against.

**Prof. Gardner**, of Rochester, explained briefly the use of the astronomical model in his school.

**Prof. H. A. Surface**, of Ithaca, explained the use of a little model made by a boy of his school, by which time can be ascertained, by means of the rays of the sun. He referred to an article on the same subject in the *Popular educator* for January and February, for a full explanation of the process.

Plans were exhibited by Prof. R. H. Cornish.

### Plans and apparatus exhibited

**From Springfield (Mass.) high school**

William Orr, instructor, plan and details of physiographic laboratory, 3 sheets

**From Holyoke (Mass.) high school**

J. T. Draper, instructor, plan of physiographic laboratory, 1 sheet

**From Worcester (Mass.) academy**

W. H. Snyder, instructor, plan of physiographic laboratory, 1 sheet; models to illustrate orthographic, stereographic and conic projections; photograph of laboratory; photographs of natural scenery, contour maps of U. S. G. S.; specimens of maps and diagrams constructed by pupils

From **Teachers college**

R. E. Dodge, instructor, lantern slides and outline maps of the "Diagram series"; mounted map (U. S. G. S.) *Junction of Mississippi and Minnesota rivers*

From **Bronx high school,** New York city

Arthur Seymour, instructor, photographs of laboratory and classroom

From **building department,** board of education, New York

C. B. J. Snyder, architect, complete floor plans of proposed high school for girls, 5 sheets; details of chemical, physical, biologic and physiographic laboratories, 3 sheets; large scale drawing of physiographic laboratory, girls high school, 1 sheet

From **Girls high school,** New York

R. H. Cornish, instructor, specimen maps from teaching equipment, as follows — U. S. coast survey; U. S. geological survey; Atlantic ocean pilot chart; physiographic folio 1; lake survey map, blank weather map; specimens of pupils' work

From **G. S. Gardner,** 141 Clifton st., Rochester

1 apparatus to show change of seasons and earth's motions

From **H. A. Surface,** Ithaca

1 apparatus to measure sun's azimuth and altitude; explained in *Popular educator,* Boston, for January and February, 1899

### GENERAL SESSION

**Friday, 3.30 p. m.**

## REPORT OF THE COMMITTEE OF NINE

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Your committee of nine appointed to study the following subjects: 1) nature study in the elementary schools; 2) science courses in secondary schools; 3) recognition of science as a requirement for entrance to college, have the honor to submit the following report.

During the year which closes today your committee have finished their discussion of "science courses in secondary schools", and beg leave to submit the following synopsis of work on the three subjects assigned to them at the outset.

The committee were appointed in pursuance of action at the first annual meeting of the association in December 1896. The first step in the investigation was designed to reveal the actual conditions of nature study, and science teaching in the elementary and secondary schools, and the attitude of the colleges toward school science. It consisted in soliciting information from about 200 teachers, principals, superintendents and others prominent in educational work, chiefly but not wholly in the cities and large towns of the state of New York. The responses were prompt, hearty and instructive, and furnished sufficient data to warrant a preliminary report discussing some of the fundamental questions relating to the subjects in hand, and presenting a provisional outline of the future work of the committee.

The committee were appointed in June 1897, and made this preliminary report in December following, at the second annual meeting. The report was published in April 1898 (*Journal of pedagogy*, 11 : 119).

A large part of that report was devoted to nature study in the elementary schools. It was shown that the concensus of opinion, according to the data gathered by the committee, is that the study of nature is an indispensable element in the education of children, but that there are great difficulties in the way of continuous and systematic nature study in the grades, arising from limitations in time, in facilities for the work, and above all, from a lack of special preparation of the teachers.

Another large part of the report was devoted to laboratory study in the secondary schools, pointing out the fact that, while the laboratory method is almost universally approved by the science teachers, the textbook method prevails in the schools, to such an extent that laboratory work is incidental, inefficient, and in many cases excluded altogether. It seemed that dissatisfaction with the existing condition of science in the schools was felt everywhere, while no consensus of opinion prevailed in regard to the nature of the fundamental difficulty, or the way to set about the improvement of science teaching.

A comparison of the courses and methods of teaching described in the communications sent in, revealed a great diversity of opinions on some of the most vital questions, such as what educational results we ought to expect from science in the schools; what ought to be taught; how it should be taught, or why any particular subject should be taught at all. Moreover, it appeared that a large number of science teachers had never been educated for their work, were overloaded with classes in other subjects and therefore could not be expected to mark out the best courses, nor to employ the best methods of teaching.

These considerations led to the belief that the first necessary step in the solution of the problem, would be to help the science teachers to obtain clear views of what science is good for in education and help them outline better courses of study and direct them to better methods of teaching. Accordingly the committee determined to do three things:

1 To define the educational aims of each branch

2. To point out right methods of teaching

3 To arrange a logical and suggestive outline of topics and exercises for each course

This plan was approved by the association at its second annual meeting and the committee entered on its execution immediately thereafter. Each branch of science was at once submitted to a special subcommittee, which was appointed by the chairman and approved by the committee of nine. The reports of the subcommittees on nature study, botany, physical geography, geology and physics are embodied in the report of the committee of nine to the association at its third annual meeting in

December 1898. That report contained the recommendation of the committee on college entrance requirements in science also. It can be found in the proceedings of the third annual conference of the association, published by the University of the State of New York, November 1899.

Early in the present year the subcommittees on zoology and chemistry were organized and proceeded to make a careful study of the secondary school courses in these branches. The subcommittee on physics also, have finished their work, a preliminary outline of which was presented last year. These three reports to the committee of nine are herewith transmitted to the association. They have been read, discussed and approved by vote, each in its appropriate section of the association at this meeting. The zeal of the subcommittees can not be too highly commended. Their work has been patient and prolonged and their reports express the deliberate judgment of competent authorities on the aims and methods of school science teaching in each branch.

## REPORTS OF THE SUBCOMMITTEES

### CHEMISTRY

*To the committee of nine:*

Your subcommittee appointed to discuss the secondary school course in chemistry submit the following report:

**Purposes** of the course. § 1 Chemistry in the secondary school will yield its best educational results only when the course is planned and conducted with intelligent regard to the following purposes:

1 To train the mind of the pupil to habits of *a*) accurate observation, *b*) logical inference and *c*) *correct and clear expression of thought.*

2 To acquaint the pupil so thoroughly and accurately with the fundamental facts and principles of the science that his elementary course will put him in position to go on with higher courses, if he shall elect to do so, or to follow intelligently the general literature of the subject if no farther special study awaits him.

3 To set before the pupil so much of the applications of chemistry as is needed to establish the fact that what he is studying is not merely a formal science of nature but a living energy in industrial and social progress.

4 And finally, by a wise selection of subject-matter and skilful teaching, to make the study of material things attractive; to impart a large fund of useful knowledge; and to promote manual dexterity and habits of care and neatness.

§ 2 A wise combination of oral instruction and textbook study, involving experimental illustrations by the teacher, a skilful use of the laboratory and a judicious incorporation of library reading are the indispensable means to attain these purposes.

§ 3 In all exercises, whether lecture, library, laboratory or recitation methods are used, mental discipline should be a prominent purpose. It is true that the teacher can not impart discipline. Mental discipline, like muscular strength and skill, can be acquired only by personal exercise. But the teacher can see that judicious mental exercises are practised by the pupil; he should lose no opportunity to give hints and directions which will enable the pupil more readily and surely to attain the desired end.

**Laboratory study.** § 4 Laboratory study is the best exercise to develop a skilful use of the senses, and establish habits of clear thinking about observed facts, and of accurate expression of thoughts inspired by personal observation. The pupil feels a certain mental responsibility for the facts to be observed in his own experiment which is absent when the experiment is made for him in the classroom. The vivid reality of the facts revealed by his own work stimulates thought more powerfully than does the impression made by facts from any other source, while, at the same time, personal observations and original thoughts are more likely than others to find clear expression. Hence to secure accurate perception, clear thinking and both accurate and clear expression, is a dominant purpose of the laboratory work.

But the laboratory work should also serve to give the beginner in chemistry a more familiar and real knowledge of some of the fundamental principles than can be obtained from the study of books alone, and, at the same time, it should acquaint him with the experimental methods of reaching truth. The promotion of manual dexterity and habits of neatness and care should not be neglected.

Other purposes of the course in chemistry, such as the acquisition of a wide range of information and the promotion of interest in the study of nature, would better be secured by the use of lecture, textbook and library methods.

§ 5 Laboratory experiments should be chosen with a view to

1 Their contents. Each experiment should involve *definite* conditions and *important* facts which will surely and distinctly appear when those conditions are furnished.

2 Their relations to the neighboring experiments in the course. They should be such as will enable the student just as far as possible to compare, to discriminate, and to put into logical relations such observed truths as will lead him to a valuable generalization.

3 Their demands for apparatus. The secondary school laboratory should be equipped with apparatus which is both scientific and inexpensive. The pieces should be neat, simple, easily put together and, at the same time, such as will exhibit really good scientific results. Such apparatus can be purchased at very moderate prices.

§ 6 Laboratory study should sometimes be devoted to the *verification* of facts and principles, but it should for the most part be devoted to original observation, comparison and inference. In either case it requires preparation. When verification is its purpose, the laboratory work should be preceded by a careful study of the facts to be verified and specific instruction in the manipulations required.

When exercise in observation, comparison and inference is its purpose, the laboratory work should precede all other sources of information on the particular facts involved in the experimental work. Foreknowledge of the results which are to occur in an experiment is fatal to independent observation and original thought. The mind shrinks from the difficult thinking which is required to deduce facts and principles from experiment and will surely falter before the task of originating clear and correct expression of its observations and inferences, if the facts and principles have been previously formulated for it by the textbook or the teacher. In laboratory work shield the student, as far as possible, from the influence of prejudice and authority.

**Laboratory study requires preparation.** § 7 The preparation of the pupil for laboratory work for the sake of observation and inference should consist of definite information from the teacher as to

1 The specific purpose or object of each exercise.

2 The apparatus required and how to use it. While the method of making each experiment should be carefully described, the results should be left for the pupil to observe and describe.

§ 8 Each student should record his work in a notebook which should be devoted exclusively to laboratory work. The record should contain a chronologic, accurate, brief but self-explanatory account of the actual work done. This brief record should be made, invariably, during the progress of the experiment or immediately following the operations and observations on which the notes are made. The most concise but accurate descriptions, reasonings and conclusions, *in good English,* which the student is competent to give, should be insisted on, but when the laboratory hours are short these may be written afterward. Let the right hand page of the notebook be systematically devoted to this purpose.

§ 9 Laboratory work in chemistry will be of little value unless it be accompanied by constant and judicious personal instruction in the laboratory and followed by thorough discussion in the classroom.

Students tend to fall into habits of purely mechanical work. If left to themselves they often follow directions as if they were recipes and record their work in a thoughtless and perfunctory manner. To resist this tendency is the most exacting and difficult task of the teacher.

§ 10 It must not be supposed that the experiments of beginners in chemistry can be accurate enough or exhaustive enough to establish the "laws of nature" or to furnish more than presumptive proof of any general principle. *Let this fact be made known distinctly to the student,* together with the reasons for it, such as

The lack of skill incident to the early stages of the study

The inadequacy of the apparatus available for elementary work

The paucity of the necessary precautions to avoid sources of error

The meagerness of the experimental data obtained, on account of limitation in the time allotted to the work.

Nevertheless several quantitative experiments should be given during the course which the pupil is required faithfully to work through, so as to approach as nearly as possible a confirmation of the law or principle involved, as, for example, the "law of definite proportions."

In this connection there should be no failure to acquaint the student with appropriate examples of expert investigations to show him how trustworthy are the results of true scientific research.

By these means our elementary laboratory exercises will tend to establish correct habits of investigation, and the use of simple, accurate and terse English in expressing results, and at the same time point the way to higher attainments in the art of discovering truth.

**Lectures and textbooks.** § 11 The laboratory work, to be fruitful, must be specific and thoroughly well done. It will not admit of haste, and in the nature of the case it can cover but a narrow and limited portion of the field. It ought to acquaint the pupil with the methods of both the work and thought involved in experimental chemistry, but it can not, unaided, acquaint him with the science of chemistry even in its elemental phases, nor with its common applications, which so supremely affect the industrial and social conditions in which he is to live and work.

§ 12 Many of the most important fundamental facts and principles are beyond the reach of the student's laboratory investigation for lack either of time or complicated apparatus or the necessary skill in manipulation. These should be demonstrated by the instructor for the class. We regard these classroom experiments as an indispensable part of the course. They should serve to broaden and deepen the student's knowledge, and to quicken his interest in the science.

§ 13 A good textbook is essential. The plainest, most logical and accurate outline of fundamental facts, principles and explanations should be used. It should not be a fragmentary outline of the subject, but a work that gives a continuous, inductive treatment, within the comprehension of secondary school pupils.

There should be a library at hand containing judiciously selected works, some of which are popular in nature, others historic and others biographic. There should be books describing chemical processes in the arts and industries, and textbooks of the same grade as the one in use but which present the elements of the science from a different point of view, and others that are advanced and exhaustive. These will help to stimulate the interest of the student, crystallize his knowledge, and, what is equally important, dispel the idea that his high school course covers all that is worth doing or knowing in chemistry.

**Time allotment.** § 14 It is in the highest degree desirable that the time allotted by the student to an elementary course in chemistry in the secondary school, including classroom, laboratory and outside study, *should not be less* than 270 hours, each of 60 minutes. The division of these hours among laboratory, classroom exercises and outside study must probably vary somewhat to meet the exigencies of the schedules in different schools, but there should always be an equivalent of five exercises a week. Two of these, each consisting of one double period, should be in the laboratory, and three, each of one single period, in the classroom, with an allowance for outside textbook and library study. At least one of these single periods should be devoted to oral instruction, including the preparatory directions for the laboratory work, and the demonstrations referred to above in § 12. The two remaining periods may be devoted to recitations. With periods of sufficient length and five a week, this may be accomplished in one year.

For example: suppose the period to be 45 minutes, that there are five a week and 36 weeks in the school year. Then

| | | |
|---|---|---|
| Two double periods (each 45 minutes) a week for 36 weeks | 108 | laboratory |
| Three single periods (each 45 minutes) a week for 36 weeks | 81 | classroom |
| Textbook and library study for 36 weeks | 81 | |
| Minimum total time by the student | 270 | hours of 60 minutes each |

§ 15 With shorter periods or a less number of them, more than a school year will be required to complete the course. With longer periods the minimum of study will be exceeded. Nevertheless we should insist on the full year for the elementary course, because it must be remembered that time is itself an element in the development of mind. A healthy increase of energy requires not only judicious supplies of nourishment, but also abundant time for assimilation and prolonged exercise, and any practicable increase in the length of the school period will not warrant the compression of the single year elementary course into a fraction of a school year.

**Subject-matter.** § 16 No mistake is more common and none more disastrous than the practice of carrying beginners in chemistry over the details of the whole science in a one year elementary course. The practice arose when science teaching was struggling for existence and was tolerated in the schools only as a source of useful and interesting information. That struggle is over but the practice continues, and to it must be attributed many of the failures of the science as an educational subject.

§ 17 Remember the specific purposes of the course (§ 1) and heroically eliminate all subjects which do not exhibit marked adaptation to these ends.

§ 18 Facts and principles which have been established on purely experimental observations should prevail throughout the course. Theories should be introduced with extreme caution and treated only in the elementary way. Even the atomic theory is unnecessary in the beginners course, because the fundamental facts relating to combining weights, laws of combination, reactions, and the characteristics of elements and compounds singly or in groups can be established and applied without it, and even formulas and equations can be most intelligently used simply to represent observed quantitative facts. On the other hand to reach a theory through inadequate facts and reasonings is to lure the student into an unhealthy mental habit.

**Outline of subject-matter.** § 19 The subcommittee offer the following syllabus of a one year course in elementary chemistry.

Many schools will find the outline brief enough to allow a considerable expansion of some topics, or the introduction of additional subjects at the discretion of the teachers. An extension of the study of characteristic properties by the use of qualitative tests for the identification of substances, and an increase in the number of experiments in *quantitative chemistry* are recommended.

The elements of organic chemistry is a worthy additional subject, provided the completion of the outlined course is not prevented by its introduction. The majority of the subcommittee do not recommend the formal study of qualitative analysis in the one year secondary school course in chemistry.

The subcommittee recommend that the course outlined below be adopted as a minimum course in chemistry for one year of five hours a week, in the secondary schools.

*Note.* Those subjects marked (c) should be illustrated by experiments in the classroom. Those marked (l) are fit subjects for laboratory work. Those marked (c) (l) may be either classroom or laboratory exercises. Sometimes both would be better than either alone.

### 1 PRELIMINARY MANIPULATIONS. FACTS, DEFINITIONS AND PRINCIPLES

*a* Chemical changes

- (c) Properties of matter
- (l) Physical and chemical changes
- (c) (l) Material products of chemical change
    - Methods of isolating them, viz
    - Decantation, filtration, evaporation, distillation
- (c) Energies involved in chemical change
    - Heat as a cause, also a product
    - Light as a cause, also as a product
    - Electricity as a cause, also a product
- The "law of conservation of matter" (lecture, library)
    - Evidence obtained from quantitative experiments
- The "law of conservation of energy" (lecture, library)
    - Evidence obtained from quantitative experiments

*b* Description of oxygen

- (c) (l) Preparation and collection. Physical and chemical properties
- (c) Allotropism
- (c) Oxidation. Oxids and their names
- Occurrence in nature
- The symbol as an abbreviation of the name. Symbols
- History and discovery of oxygen (library)

*c* Description of hydrogen

(c) (l) Preparation by mutual action of dilute sulfuric acid and zinc. Collection. Physical and chemical properties

(l) Comparison with oxygen. Distinguishing properties and tests

Occurrence in nature

*d* Description of water

(c) Produced by burning hydrogen in air or oxygen
Contains both of these substances
Compared with oxygen and hydrogen
Elements and compounds defined
Natural waters are mixtures of water with other substances

(c) Sanitary and unsanitary water. Tests

(l) Purification by distillation, by filtration

(c) Water as a solvent. Other solvents

(l) Crystallization. Efflorescence. Deliquescence

(c) Synthesis of water, taking all necessary precautions in the measurement of gases. Proportions by volume. Computation of relative masses, knowing relative volumes and densities of the gases

(l) Analysis of water by electric current, accurately measuring the volumes of the gases obtained. Inquire for any reason why the true volumes are not obtained. Compute the relative masses of oxygen and hydrogen. Compare with the results by synthesis

(c) (l) Results confirmed by action of dry hydrogen on dry copper oxid by heat

The "law of definite proportions" by weight

Corollary: Even the *smallest conceivable portion* of a compound must contain its constituents in definite relative proportions. Every body is supposed to be made up of such little masses, called molecules.

Refer to the electrolysis of water, which shows that the molecules are broken up. The smallest pieces of oxygen and hydrogen in the molecules are called *atoms*

(Note. In this way the terms molecule and atom come to stand for distinct and useful ideas, though an adequate discussion of the atomic theory is impossible for lack of facts)

The volumetric composition of water including the condensation from three volumes to two

*e* Description of nitrogen

- (c) (l) Preparation by burning phosphorus. Physical and chemical properties
- (l) Comparison with oxygen and hydrogen. Distinguishing properties and tests
- Occurrence in nature

*f* Description of the air

- (c) Proof by burning phosphorus that air contains oxygen and nitrogen
- (c) Proof of other constituents: water, carbon dioxid
- (c) Evidence that air is a mixture of its constituents
- (c) Relative proportions of oxygen and nitrogen found by slow combustion of phosphorus
- (l) More exact analysis of air by alkaline pyrogallic acid (Cooley's experiment)
- (c) Diffusion of gases
- Respiration (ventilation)
- Mutual action of air and plants

*g* Description of nitric acid

- (c) Preparation from sodium nitrate
- (l) Properties
- (l) Decomposition: by metals, by sunlight: nitrates (mentioned here, see 2, *i*)

*h* Nitrogen oxids (briefly)

(1) Preparation of nitric oxid and nitrogen peroxid by action of nitric acid and copper

Compositions and names of the five nitrogen oxids

*The "law of multiple proportions"*

Combining weights defined

A symbol to represent one combining weight of an element.

A formula to represent the names and number of combining weights of the constituents in a compound as found by experiment

The chemical equation, to represent *experimental facts* only. Examples drawn from former experiments such as preparation of oxygen

Solution of chemical problems

*i* Combination by volume

Use the results obtained for water (p. 717) and add

(c) Volume relations in the composition of hydrochloric acid

(c) Volume relations in the composition of ammonia

*Statement of the law* (Guy Lussac's law)

*j* Specific gravity of gases

(1) Determine the specific gravity of a gas (illuminating)

Relation between specific gravities and combining weights of gaseous elements

*Avogardo's law*

*k* Review critically Boyle's law, and Charles's law, and lead up to a simple statement of the atomic theory offered as the most probable explanation of the facts of definite and multiple proportions

Distinguish between facts, laws, hypotheses and theories

*l* Acids, bases, salts

Mutual chemical action of some oxids and some metals with water

(1) Burn sulfur in *dry* oxygen. Represent the facts by an equation (taking the name and composition of the oxid on authority)

Test the product by *dry* litmus paper. Afterward test it with *wet* litmus paper. Test it by taste: using it very much diluted. Represent the combination of the oxid with the water

(c) Oxidation of other elements, not "metals," in presence of water. By comparison discover the common properties. *Acids.* Also hydroxids. Nomenclature of acids

(1) Action of sodium on water

Collect and test the gaseous product. Isolate the solid product by evaporating the water to dryness. Test this product by taste and litmus. Represent the facts by an equation (taking the name and the composition of the solid on authority)

(c) Other substances with similar composition and properties

*Bases.* Also *hydroxids*

Nomenclature of bases

(1) Neutralize a solution of NaOH by HCl in *slight* excess. Isolate one product by evaporation to complete *dryness.* Identify by its familiar taste. Show by litmus that it is neither acid nor base. Represent the facts by an equation, taking the name of the liquid product on authority

(c) Mutual action of other acids and bases

Products of the reactions, water and *salts*

Nomenclature of salts

*m* Reaction between acids and metals. Substitution

(1) Of zinc and sulfuric acid

Completely dissolve a known mass of pure zinc in dilute sulfuric acid and carefully measure the H.

evolved. Isolate the solid product by evaporation to crystallization. Zinc sulfate — a *salt*. Represent the facts by an equation. Compute the mass of the H. Compute the mass of hydrogen which one combining weight of zinc (see table) would displace. Consider *how many combining weights of H this mass* of H represents.

(c) Mutual action of other metals and acids
  The products are water and *salts*
  The reaction consists in a *substitution* of metal for hydrogen
  Definite number of combining weights of H being equivalent to one combining weight of the metal
  (Call attention to similar facts as they appear in the future, for the sake of *valence*, which must be considered in due time)

### 2 DESCRIPTIONS OF ELEMENTS AND COMPOUNDS

*a* Chlorin

(1) Preparation from NaCl. Physical properties
  Chemical properties
(c) (1) Energetic attraction for metals
  Chlorids and their names
(c) Energetic attraction for hydrogen
(c) (1) Preparation and properties of HCl pure and commercial acid
  Composition represented by a formula
(c) Bleaching and disinfecting. Chlorid of lime
(c) Chlorin oxids and acids (briefly) illustrating multiple proportion. Example of a chemical series
Occurrence in nature

*b* Bromin and its compounds (briefly)

(c) Preparation from sodium bromid

(c) Physical and chemical properties

Composition of bromids and hydrobromic acid

Occurrence in nature

*c* Iodin and its compounds. (Topics same as for bromin)

*d* Fluorin and hydrofluoric acid (briefly)

*e* Comparison of chlorin, bromin, iodin and fluorin

Similarity in their physical properties

Similarity in their chemical actions

One combining weight of each to one of H

Progressive diminution of chemical energy with progressive increase of combining weight

Curious numerical relation: the combining weight of bromin a mean between chlorin and iodin

*A natural group of elements*

**(Call attention to similar natural groups as they shall be met along the way, for the sake of the *periodic law* which is to be considered in due time)**

*f* Sulfur and its compounds

Occurrence of sulfur in nature

Commercial preparation and forms

(c) Effects of heat: allotropism (Compare oxygen and carbon)

(c) Solubility: crystals: dimorphism

(l) Attraction for metals: sulfids

(l) *Hydrogen sulfid.* Preparation and properties

Composition: analogous to that of water

(l) Decomposed by metals: yielding sulfids and water

(l) Decomposed by salts in solution, yielding sulfids and acids

(l) Used to identify the metals in compounds

(c) Action on basic hydroxids yielding *hydrosulfids* and water

Substitution of sulfur for oxygen, combining weights 1 for 1

(c) (l) *Sulfur dioxid.* Refer to burning of sulfur in oxygen. Preparation by heating copper and sulfuric acid. Properties and composition

(c) (l) Its solution in water, sulfurous acid — neutralized by bases — salts called sulfites produced

(c) (l) Bleaching by dioxid

*Sulfuric acid and sulfates.* Properties and uses of the acid

(c) Manufacture: operations and reactions involved

(c) Mutual action of water and sulfuric acid

(l) Mutual action with iron yielding *ferrous sulfate* and hydrogen

(l) Mutual action with copper (See prep. sulfur dioxid) Isolate the copper compound left in solution. *Copper sulfate* and water the products of the reaction

(c) One or both combining weights of the hydrogen may be displaced by the metal

*Normal and acid salts*

Monobasic and dibasic acids

*g* Selenium and tellurium mentioned

(Chiefly because needed to illustrate the natural group. Such facts would better be accumulated along the way for the sake of the *periodic law,* which is to be presented in due time)

*h* Comparisons of sulfur, selenium, tellurium and oxygen

Similarity of sulfur and oxygen in chemical action

Similarity of sulfur, selenium, tellurium shown by their hydrogen and oxygen compounds

Progressive diminution of chemical energy with increase of combining weights (a second example)

**Oxygen, sulfur, selenium and tellurium a *natural group of elements***

*i* **Nitrogen and its compounds**

Description of nitrogen: refer to 1, *e*

Compound of nitrogen and hydrogen: ammonia

(1) Preparation by heating a mixture of slaked lime and ammonium chlorid. Properties and composition

(1) Solubility in water, a basic hydroxid

Ammonium salts

Analogy of ammonium to the metals

Direct combination of nitrogen and hydrogen by silent electric discharge (Atmospheric)

Ammonia produced in decay of animal substances

*Nitric acids and nitrates*

Description of nitric acid: recall 1, *g*

Properties and use of commercial nitric acid

(c) (1) Preparation by action of a less volatile acid (sulfuric) on a nitrate (sodium)

(c) (1) Nitric acid as an oxidizing agent. Yields an oxid, water and compounds of N and O, generally nitric oxid. Examples, charcoal

(c) The action of nitric acid and metals. Generally yields a nitrate (copper), but sometimes a metallic oxid (tin), accompanied by water and nitric oxid or other oxids of nitrogen

Compare with the actions of sulfuric and hydrochloric acids on metals

*Nitrification* by minute organisms in soils

by lightning discharges

*j* Phosphorus

Occurrence. Manufacture. Physical properties. Allotropism

(Recall other allotropic elements)

(c) Phosphorus and hydrogen: phosphin
  Phosphorus and oxygen: oxids and acids
  Phosphates
  Matches

*k* Arsenic

Occurrence in nature
Properties of the element
(c) Arsenic and hydrogen: arsin
(c) Arsenic and oxygen: oxid, acid, arsenites
(l) Tests for arsenic

*l* Antimony (briefly)

*m* Bismuth (briefly)

*n* Comparison of N, P, As, Sb and Bi.[1] Chemical resemblances shown by the similar composition of their hydrogen compounds

Progressive change in specific gravities with increase of combining weights
Progressive change from strong acid to basic character of the oxids, with increase of combining weights
These five elements constitute a *natural group*

*o* Carbon

Occurrence in nature
(l) Preparation of charcoal by heating wood in the absence of air

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[1] Facts needed in order to make this comparison can be found in books for reference.

(c) (1) Properties: absorption of gases, of coloring matter
Uses based on these properties
Allotropism
(1) Action of hot carbon on copper oxid
*Reduction and reducing* agents
(c) Combustion: heat produced; how measured, constant value for each kind of fuel

Carbon dioxid
Occurrence in nature: sources
(1) Preparation by action of marble with acids
(1) Physical and chemical properties
(1) Distinguishing properties and tests
(c) Carbon monoxid

*p* Silicon

Occurrence in nature
Silicon dioxid: gems
Silicic acid: silicates, soluble and insoluble: glass

*q* Chemical resemblance between silicon and carbon, shown by comparing the composition of their hydrogen and their oxygen compounds
Similar chemical properties in a few rare elements
*A fourth natural group of elements*

### 8 VALENCE AND THE PERIODIC LAW

*a* Valence

**(This principle should be treated briefly in the secondary school course, simply as an inference from observed facts, the teacher having emphasized the relation of the numbers of combining weights taking part in reactions, at the time those facts were observed.)**

Recall facts bearing on the principle, such as in substitution of zinc for hydrogen

Comparison of the number of combining weights of hydrogen which unite with one combining weight of chlorin, oxygen, nitrogen, carbon

Observe that the combining weights of the elements are able to unite with different but definite numbers of combining weights of hydrogen

*Define valence* as the ability of the combining weight of an element to unite with a definite number of combining weights of hydrogen: nomenclature

Valence as a characteristic of a *definite quantity* of an element. This quantity, from the experimental standpoint, is represented by the *combining weight* (According to the atomic theory it is the atom)

*b* The periodic law

Elements having the same valence agree in other chemical character also. Hence the elements are found in families or *natural groups* (Recall the groups which have appeared along the course)

The gradation of properties in each natural group also is found to depend on the combining weights

Thus we find that combining weight — the most fundamental chemical property of matter — is the natural basis for the classification of all elements

Show how, by arranging the elements in the order of their combining weights, similar properties reappear at regular intervals. The "periodic law"

Point out the eight natural families thus identified, and the gradation of properties in each

(Be content with the foregoing empirical and brief view of valence and the periodic law, and leave the discussion of details and theoretic considerations for advanced courses.)

### 4 STUDY OF SOME OF THE SO-CALLED METALS

The classification of elements as metals and nonmetals is not wholly true to nature. Illustrate

The power to form basic instead of acid hydroxids is the most distinguishing chemical characteristic of the metals

But the gradation from distinctly acid to distinctly basic properties is unbroken (See the natural group)

An exhaustive logical study of the elements should be based on their natural relations shown by the periodic law. But such exhaustive study must be reserved for advanced courses

The following metals may be selected for study in the elementary course: *sodium*, potassium, calcium, magnesium, *zinc*, *aluminum*, *lead*, tin, *copper*, mercury, silver, gold, *iron*, manganese, chromium

The study should include the following topics

- The chief physical properties
- The principal chemical reactions
- The most important compounds
- Alloys
- Extraction of the metal from ores
- Useful commercial processes and products

More detailed study may be confined to the elements italicized in the above list.

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### PHYSICS

*To the committee of nine:*

The subcommittee on the secondary school course in physics submit the following report:

Fortunately the time has arrived when it is no longer necessary to advance in detail the arguments in favor of the teaching of science in secondary schools. Its value as an educational subject and as a source of valuable information has been fairly recognized. Still the force of conservatism is so great that even now it is not possible to obtain for the sciences the same amount of time and the same amount of energy as are accorded to Latin, and in some cases, even to Greek.

**Purposes of the course.** Each of the general branches of science has certain advantages; each is qualified to develop certain characteristics in the mind of the student. The elements of the natural sciences adapt themselves readily to younger students, inasmuch as they deal almost entirely with observation and require only a simple report of what can be seen, felt, and heard everywhere. Chemistry and physics are also adapted to the development of the powers of observation and description, but they differ from the natural sciences in that they treat of results and causes directly under the control of the experimenter. These two sciences must consequently emphasize in the mind of the student the absolute certainty of cause and effect; the fact that the laws of nature never have exceptions; and that the same result always follows from the same cause or combination of causes.

But these characteristics belong to these two sciences in different degrees. In chemistry the operations are, in the main, similar. They all belong to a few general classes, and our conclusions are drawn from combinations of similar results rather than from essentially different results. In physics, on the other hand, the range of operations is greater; the phenomena differ from one another not only as to degree, but entirely as to fundamental nature. It is true that the science of the end of the century is reducing to simpler forms the mass of observed phenomena in physics, but that does not result in rendering the phenomena similar. As an instance we are told that radiant heat, light, "actinism" and electrical vibrations are all essentially one and the same thing in their fundamental nature, but that fact does not render the phenomena of heat, light, photography and electricity less varied in their essential forms of presentation to our observation.

Physics should accustom the student to trace the direct relation between cause and effect. In those cases where numerous causes combine to produce a complex effect, a variation ever so slight in one factor in the cause inevitably produces a corresponding effect in the result. If compelled to differentiate the effects due to these variations, the mind of the student acquires skill in inductive reasoning by the exercise.

Again, when the student is brought to the determination of physical quantities and is called on to present his results, he is immediately placed, to a certain extent, in temptation — the temptation to obtain a certain expected result. The gradual development in him of the habit of accepting the result obtained irrespective of whether it was expected or not, encourages and trains him in the habit of honesty and destroys any desire to do that most dishonest thing, to deceive himself.

**Characteristics of the course.** As to the nature of the course in physics which the student should follow, it should in the first place be suited to give the greatest benefit to the greatest number. This will immediately rule out of special consideration any particular college requirements. The percentage of scholars in the secondary schools who enter college is so small that they must be content with what is best for the rest of the scholars; in fact, it is best for them too. Gradually the colleges are becoming sensible that the best entrance requirement is one that will be satisfied by the course of study that is best, irrespective of whether the student is going to college or not. This principle applied to physics means that the course should be sufficiently extensive to cover the main branches, elementary mechanics, sound, light, heat and electricity and magnetism, so that the student at the end of the course may at least have a broad general view of the whole subject. This broad view should not be a smattering of many isolated, incoordinated facts; it should be obtained by the thorough, careful mastering of a few well chosen characteristic topics. It must be sufficiently specific and accurate to insure the learner against the inference that the facts of physics are approximate; he must learn that in physics quantity is quite as essential as, if not more essential than quality. The quantitative idea must be ever present in his work.

The nature of modern physics is such that a considerable maturity of mind, a previous acquaintance with mathematics and some skill in observational methods are required in preparation for the study of it. Therefore, to make the course most useful for general education and at the same time, at all satisfactory as preparation for college, physics should never be placed below the third year on the secondary school program.

**Methods of teaching.** The method of teaching should consist of classroom lectures, recitations and actual work by the student himself with the apparatus in the laboratory. The time should be divided so that approximately one half of the time is occupied by the student in the laboratory; the remainder being devoted to the lectures, and recitations on them, or on assigned work in the textbook. Many phenomena can be demonstrated to the student better by a lecture than by the student with the apparatus himself. Many facts of physics can be learned by the student from textbooks quite as well as from lecture or laboratory work. The work in the lecture room and in the laboratory should be carried on in such an elastic way that the class may devote a number of periods consecutively to lecture room, or laboratory work, as the case may require.

**Time allotment.** It is in the highest degree desirable that the total time allotted by the student to physics in the secondary school shall not be less than 270 hours, each of 60 minutes. There should be the equivalent of five exercises a week, of which at least two should be in the laboratory, and these two should be double periods. In general two laboratory periods should be considered equivalent to one scheduled lecture period with the preparation which it requires. Thus if we have 36 weeks in the school year with periods of 45 minutes, then the two double periods a week would amount to 108 hours; the three single periods in classroom to 81 hours; leaving for textbook and library study 81 hours.

Not less than one whole school year should be allotted to the course, and, if the periods are less than 45 minutes or there be less than five a week, the course should be more than the year in length.

**Helps.** The lecture work and recitations can readily be obtained from any of the numerous textbooks recently published for such courses. The laboratory work may require separate books on laboratory experiments. The teacher should choose a textbook for his classroom, on which his lectures should be based, and one for his laboratory, but he should also provide himself with several other books giving similar lecture work and similar laboratory work. No one can be sure that he has the best method of making an experiment, or a demonstration so long as he has only one way of doing it. He should himself pick and choose from the various manuals, always using his own individuality and his own modifications in the more or less important details of any experiment. In this way the teacher will develop a course of instruction, both in his lecture room, and in his laboratory, which will embody the best that can be had from textbooks, and will, at the same time, bear sufficient impress of his own individuality to convince the students that they are to be congratulated in having a particularly well chosen, and well worked out course, and one that has been devised and carried through specially for them.

**Notebooks.** The student should not be required to do much outside work on his laboratory study, and should be taught to keep his notebook record originally in good form, rather than to make memoranda on loose pieces of paper to be subsequently copied.

Each day's work should bear the date and the object of the experiment. All superfluous description of apparatus, theorizing, and deduction of formulas should be omitted.

The observations, formulas and important data and results should be put on the right hand (or left hand) page of the notebook, the opposite one being devoted to chance memoranda, preliminary readings, calculations, etc. In this way the instructor has before him for examination a complete view of the work of the student at that time.

These notebooks should be examined by the teachers as frequently as possible, and remarks entered in red ink, made where necessary. In extreme cases the pupil should repeat the experiment.

Pupils should be encouraged to preserve these books for future evidence and reference.

**Outline of subject-matter.** The following list is intended to aid and suggest rather than to fetter or dictate in the selection of work for the laboratory course in physics. It is not deemed necessary to outline the entire course in general physics, because this has been well done already by the authors of several recent textbooks.

The average student in a well equipped laboratory should be able to do about two thirds of the experiments. But good careful work should be always preferred to a long list of experiments. At least one third of the time should be devoted to mechanics; the remaining two thirds given to light, electricity, heat and sound, the most being assigned to light, the least to sound. The references to textbooks are without relation to preference, being in general arranged alphabetically. The teacher should be provided with several textbooks and choose the best explanations from all. In purchasing apparatus, several catalogues should be consulted, and the best piece of apparatus taken from each.

### *Abbreviations*

A. Laboratory manual of experimental physics, Albert L. Arey. C. W. Bardeen, Syracuse, N. Y.

A. & B. Manual of experiments in physics, J. S. Ames & W. J. A. Bliss. Harpers, New York.

C. Students' manual of physics, LeRoy C. Cooley. American book co., New York.

G. Physical experiments, Gage. Ginn & Co., Boston, Mass.

G. & S. Practical physics, Glazebrook & Shaw. Longmans, Green & Co., New York.

H. & B. Textbook of physics, Hall & Bergen. Henry Holt & Co., New York.

N. & F. Elements of physics, Nichols & Franklin. Macmillan & Co., New York.

S. A laboratory course in physics, Sabine. Ginn & Co., Boston, Mass.

S. & G. Elementary practical physics—2v, Stewart & Gee. Macmillan & Co., New York.

W. Physical laboratory practice, Worthington. Rivingtons, London, Eng.

### *Mechanics*

1 Estimation of tenths in measurements. W. 18.

*a* Measuring a distance shorter than the ruler

A. 12; A. & B. 15–26; C. 13; G. 1; H. & B. 4; S. & G. 4; W. 20.

*b* Measuring a distance longer than the ruler

A. 10; G. & S. 64; H. & B. 4.

*c* Dimensions of a parallelopiped

H. & B. 9.

2 Measuring areas and volumes

G. & S. 73; S. & G. 96, 105; G. 1–3.

*a* Of regular bodies by dimensions

H. & B. 6, 9, 10; W. 31, 43.

*b* Of irregular bodies by comparison with weight of regular body

C. 17; W. 35, 46.

*c* Of irregular bodies by overflow

H. & B. 12.

3 Micrometers and calipers to measure cylinders and spheres

A. & B. 34, 40; C. 16; G. & S. 50, 57; S. 8; S. & G. 14, 39; G. 4; W. 26.

4 *a* Principles of levers, with three cornered file, meter stick and weights
C. 60, 114; H. & B. 42, 46; W. 85; A. 64, 90; G. 30.
*b* Weighing unknown mass
A. 64; W. 85.
*c* Equal arm balance
A. & B. 17, 61; C. 21; S. & G. 63.

5 Specific gravity of liquids
*a* Tube connected above with T
A. & B. 183; H. & B. 221; G. 22; W. 63; S. & G. 142.
*b* With bottle
A. 60; C. 154; G. & S. 116; H. & B. 25; G. 23; S. & G. 127; S. 21.
*c* Weighing body in water and in the liquid
A. 60; C. 155; G. & S. 111; H. & B. 25; S. 20; W. 68.
*d* Floating rule
H. & B. 23; G. 23; W. 72.
*e* Hydrometers
C. 155; G. & S. 123; N. & F. 13.
*f* Capacity of a flask
A. & B. 22; G. & S. 78; S. & G. 107.

6 Specific gravity of solids
*a* Density of regular solid $\frac{\text{mass}}{\text{volume}}$
A. 20; A. &. B. 201; G. 2; H. & B. 15; W. 56.
*b* Of an irregular body by immersion
A. & B. 189; C. 27, 151; G. & S. 107; H. & B. 18; S. 18; S. & G. 120; W. 56, 67; A. 56; G. 20.
*c* Substance lighter than water
A. 58; C. 153; G. 21; G. & S. 109; H. & B. 20; S. & G. 137.
*d* Diameter of wire from length and specific gravity
A. 16; W. 57–67.

7 Calculating the mass of a column of air
G. & S. 153; H. & B. 234.

8 Construction and principle of the barometer
    A. 42; A. & B. 157; C. 143; G. & S. 154; H. & B. 225; S. & G. 9, 205.
    *a* Effect of elevation above sea level. A. 48.
    *b* Principle and use of verniers
        A. & B. 30, 34; N. & F. 2; S. 7; S. & G. 7.

9 Principle and action of
    *a* Siphon. C. 147; H. & B. 39.
    *b* Suction pump. C. 145; H. & B. 38, 235.
    *c* Other pumps. C. 160; H. & B. 235.

10 Liquid pressure
        A. & B. 179; C. 135, 136; H. & B. 28.
    *a* Downward. A. 30, 38.
    *b* Upward. A. 34; C. 148; G. 11.
    *c* Lateral. A. 40.
    *d* Below free surface. A. 32; G. 11; H. & B. 23.
    *e* Shape of vessel (Pascal)
        C. 140; H. & B. 217; N. & F. 106; A. 30.

11 Friction of rest and motion
        A. & B. 146; H. & B. 78; N. & F. 101; W. 110; G. 34.
    *a* Depends on area
    *b* Depends on load

12 Breaking strength of wire
    C. 84; H. & B. 181; S. & G. 197; G. 5; A. 18.

13 Elasticity of bending
    H. & B. 193; W. 129; A. 24, 28; G. 7.
    *a* Effect of length
    *b* Effect of width
    *c* Effect of thickness
    *d* Effect of material

14 Elasticity of stretching a wire
    A. & B. 163; C. 81; G. & S. 141; H. & B. 190; S. & G. 176; S. & G. 179; A. 22; G. 6.
    *a* Length

- *b* Diameter
- *c* Material

15 Elasticity of torsion of wire or rod
H. & B. 199; N. & F. 92; G. 8.
- *a* Length
- *b* Diameter
- *c* Material

16 Elasticity of gases; Boyle's law
A. & B. 209; C. 157; G. & S. 160; H. & B. 34, 228; N. & F. 108; W. 79; A. 48; G. 14.

17 Composition of forces
- *a* Parallel: with ruler and spring balances
A. & B. 129; C. 112; W. 100; A. 62.
- *b* Oblique by constructing parallelogram
H. & B. 122; C. 103; H. & B. 64; W. 95; A. 68; G. 28.

18 Moment of rotation and pair forces. H. & B. 260.

19 Center of gravity. A. & B. 136.
- *a* Regular body. C. 116; W. 105.
- *b* Irregular body by suspension. C. 117; H. & B. 45; W. 103.

20 Falling bodies, board and vibrating rod. A. & B. 70; A. 70.
- *a* Space proportional to square of time. A. 72–74.
- *b* Inclined plane
- *c* Ratio of force to acceleration. A. 72; A. & B. 98.

21 Simple pendulum. A. & B. 18; C. 125; H. & B. 86; S. 24.
- *a* Isochronism. A. 80; G. 36; W. 140.
- *b* Effect of length. C. 126; A. 82; G. 36; S. & G. 224; W. 153.
- *c* Effect of bob. W. 151.
- *d* Determination of g. C. 130.
- *e* Reversible pendulum

22 Work
- *a* Vertically. C. 39.
- *b* Inclined plane. C. 54, 65; H. & B. 70; A. 86; G. 33.

*c* Pulleys. A. & B. 141; C. 63; H. & B. 55; W. 123; A. 94.

23 Equilibrium of bodies on

*a* Level table. C. 118; H. & B. 279.

*b* Floating body. H. & B. 283; N. & F. 116; W. 69; A. 52.

24 Construction and interpretation of curves

A. & B. 6; C. 141; S. 121; G. 16.

### *Heat*

25 Testing a thermometer

A. & B. 259; C. 175; G. & S. 195; H. & B. 354; S. 44; W. 160; A. 102; G. 41.

*a* Zero point

*b* Boiling point

26 Linear expansion of a solid

A. & B. 265; G. & S. 200; H. & B. 360; A. 98; G. 42.

27 Apparent expansion of water in glass

A. & B. 271; C. 190; H. & B. 350 to 366; S. 48.

28 Curve of irregular expansion of water between 0° and 50° C. H. & B. 367; N. & F. 155.

29 Expansion of gas

*a* Constant volume. A. & B. 278; G. & S. 208; H. & B. 370; G. 45.

*b* Constant pressure. C. 171; G. & S. 210; H. & B. 373; G. 44.

30 Relative conductivity of solids for heat

C. 184; H. & B. 349; G. 40; W. 159.

31 Study and illustration of convection currents

C. 187; H. & B. 346.

32 Phenomena of boiling: C. 199; G. 48.

*a* Formation of air bubbles

*b* Singing

*c* Evaporation

*d* Distillation. H. & B. 407.

33 Specific heat
  *a* Of solids by mixture
    A. & B. 282; C. 180; G. & S. 212; H. & B. 384; N. & F. 164; S. 50; W. 177; A. 114; G. 49.
  *b* Of liquids by mixture
    A. & B. 288; C. 177; H. & B. 387; W. 182.

34 Latent heat
  *a* Of water by mixing with ice
    A. & B. 295; G. & S. 219; H. & B. 394; S. 51; W. 185; A. 108; G. 52.
  *b* Of steam by condensation
    A. & B. 302; C. 197; G. & S. 221; H. & B. 410; W. 181; A. 110; G. 55.

35 Relative humidity. G. & S. 232.
  *a* Dew point. H. & B. 405; G. 49.
  *b* Wet and dry bulb thermometers. G. & S. 238.

36 Maximum and minimum thermometers

37 Cooling by forced liquefaction
  *a* Salt and ice. W. 187.
  *b* Solution. (Ammonium nitrite)

38 Newton's law of cooling by radiation
    A. & B. 311; G. & S. 225; S. 52; W. 163.

### *Sound*

39 Velocity of sound
  *a* Out of doors. C. 211; H. & B. 442; A. 128; G. 76.
  *b* By resonance in tube with water
    A. & B. 223; C. 219; G. & S. 172; H. & B. 451; S. 37; A. 132; G. 77.
  *c* In a rod. A. & B. 239; S. 39.

40 Monochord, pitch of string depends on
  *a* Length
  *b* Tension
  *c* Mass

A. & B. 226; A. 116-20; C. 227; G. & S. 175; H. & B. 463; G. 80.

**41 Pitch of tuning fork**

- *a* By trace in lampblack. H. & B. 456; A. 124; G. 77.
- *b* By comparison on monochord. S. 33.

**42 Lissajou's figures**

**43 Chaldni's figures.** H. & B. 463.

*Light*

**44 Law of inverse squares.** C. 245; H. & B. 95.

**45 Photometers**

- *a* Rumford. C. 247; G. & S. 248; H. & B. 96; A. 136.
- *b* Bunsen. C. 248; G. & S. 244; H. & B. 98; S. 45; G. 82.

**46 Laws of reflection of light from**

- *a* Plane surface
  A. & B. 431; C. 250; G. & S. 250; H. & B. 103; A. 140; G. 84.
- *b* Curved surface
  A. & B. 436; C. 257; H. & B. 111.
- *c* Focal length of concave mirror.
  C. 258; G. & S. 261; H. & B. 118; S. 62; G. 85.

**47 Refraction.** G. 89.

- *a* With plate of glass. A. & B. 442; C. 267; H. & B. 127.
- *b* With prism. A. & B. 474; C. 269.
- *c* Index of refraction. A. & B. 446; H. & B. 127.

48 Wave length of sodium light with simple grating
A. & B. 477.

49 Focal length of convex lens. C. 272.

- *a* Parallel light. G. & S. 267; H. & B. 138; A. 144; G. 91.
- *b* Conjugate foci
  C. 269; G. & S. 268; H. & B. 141; A. 148; G. 92.

**50 Magnifying power**

- *a* Of a simple lens. G. & S. 283; S. 71.

*b* Of a miscroscope, telescope, or opera glass
G. & S. 279; S. 75; G. 97.

### *Electricity*

51 Lines of force around
*a* Magnets of various shapes
A. & B. 344; C. 367; N. & F. 2: 27; S. 80; S. & G. 2: 24; W. 230; A. 152; G. 57; H. & B. 476.
*b* Magnet and soft iron
S. & G: 25; W. 219, 230.
*c* Coil or wire carrying current
C. 386; H. & B. 522; N. & F. 2: 31.

52 Plotting a magnetic field in a room by swinging a bar magnet
A. & B. 356; N. & F. 2: 97.

53 Static electricity. C. 302.
*a* Gold-leaf electroscope
A. & B. 328; C. 311; H. & B. 486; S. & G. 2: 4; W. 252; S. & G. 2: 2; W. 255.
*b* Induction
A. & B. 328; C. 311; H. & B. 486; S. & G. 2: 4; W. 252.
*c* Relative potential when rubbed
S. & G. 2: 14; W. 250.
*d* Both kinds always liberated
S. & G. 2: 13; W. 249, 266.

54 Electric batteries. C. 329; H. & B. 504; S. & G. 2: 55; G. 67; A. 164.
*a* Different metals, same liquid. C. 338.
*b* Different liquids, same metals. C. 338.

55 Oersted's experiment on deflection of needle by electric current
C. 334; S. & G. 2: 61; W. 275; G. 60.

56 Resistance. C. 345; G. 65.
*a* Effect of length of wire. A. & B. 365; H. & B. 531; W. 282; A. 178.
*b* Effect of diameter of wire. A. & B. 371; H. & B. 532; W. 283; A. 178.

*c* Effect of material of wire. A. & B. 371; W. 283; A. 180.
*d* By substitution. H. & B. 531.

57 Measurement of electric current by; A. & B. 402.
*a* Tangent compass. S. & G. 2: 225.
*b* Copper voltameter. G. & S. 408; H. & B. 516; N. & F. 2: 87; S. & G. 2: 251; A. 156.
*c* Water voltameter. H. & B. 516; N. & F. 2: 87; S. & G. 2: 255; C. 340.

58 Factor of a galvanometer. G. & S. 405; S. & G. 2: 98, 268; A. 168.

59 Electromotive force (pressure) comparison
A. & B. 392; C. 358; G. & S. 436; H. & B. 324; S. & G. 2: 101.
*a* By deflection, resistance being constant
*b* By resistance, deflection being constant

60 Combination of cells for greatest efficiency
H. & B. 524, 542; S. 10; S. & G. 2: 76; A. 166; G. 68; C. 342.

61 Resistance determinations by the wheatstone bridge
A. & B. 373; C. 356; H. & B. 538; S. 95; S. & G. 2: 107; W. 281; A. 176.

62 Effect of temperature on resistance
H. & B. 539; S. 100; W. 285; G. 70; C. 357.

63 Induced currents. C. 388; H. & B. 558.

64 Determination by fall of potential of
*a* Current
*b* Resistance. A. 172; S. 94.

65 Logarithmic decrement. S. & G. 77; G. & S. 469; A. & B. 505.

66 Efficiency curve of an electric cell (Polarization curve of a cell). G. 60; A. 160.

### *Apparatus*

Dealers' addresses, arranged alphabetically

Crowell apparatus co., Indianapolis Ind.

Franklin educational co., 5 Hamilton place, Boston; 250 Wabash av. Chicago, Ill.

Gaernten & Co., William, 152 56th st. Chicago Ill.

L. E. Knott apparatus co., 14 Ashburton place, Boston Mass.

Alfred L. Robbins Co. 149 E. Huron st. Chicago Ill.

### *Mensuration*

Areas

Circle = 3.14 times square of radius
Sphere = 4 times 3.16 square of radius
Parallelogram = hight times base
Triangle = half hight times base
Trapezium = hight times average of top and base

Volumes

Sphere = $\frac{4}{3}$ times 3.14 times cube of radius
Parallelopiped = area of any side times perpendicular distance to the opposite one
Pyramid = area of base times $\frac{1}{3}$ hight
Cylinder = area of base times hight
Cone = area of base times $\frac{1}{3}$ altitude

William Hallock
LeRoy C. Cooley
Albert L. Arey
Irving P. Bishop
} *Subcommittee on physics*

## ZOOLOGY

*To the committee of nine:*

The subcommittee on zoology have the honor to present the following report, which discusses the method of instruction and the subject-matter of a course of field and laboratory study in this branch of science suitable for the second or third year of the high school. That the suggestions made in this report do not relate to purely ideal conditions is shown by the fact that courses in zoology similar in all essential features to the one here outlined are at present given in various high schools throughout the country.

**General method.** Zoology, in common with other branches of science, should be taught by the scientific method, by which is meant the method that puts the pupil in position to discover the truth for himself and holds him responsible for a certain amount of personal investigation. In this way only can scientific habits of study and of thought be developed. Any other method makes the pupil merely a repository of memorized facts culled from books and gives him little power to do independent thinking.

The essential features of the scientific method are

1 *Observation,* to furnish the mind with its primary facts. In dealing with classes the teacher will find that very few pupils possess the power of observing correctly, that is, of seeing a thing as it is and not as they think it ought to be. The first observations of a class, then, must usually be made with the aid of suggestive questions by the teacher. Later, when some experience has been acquired, the pupil should be expected to do independent work. Along with simple observation goes observation controlled by experiment, when conditions are varied one after another in order to determine to what extent the first observation is correct. Experiment implies the invention of a hypothesis, whose truth or falsity appears when the conditions are varied.

2 *Distinction* between essentials and non-essentials, or, as applied in zoology, choosing the distinguishing characteristics of structure and function in an animal. This necessitates a careful comparison of forms and requires a thorough knowledge of the various animals studied. To the beginner all facts of observation are of equal value, and his training must be so directed as to enable him to recognize the important though often obscure or hidden characteristics.

3 *Comparison* of results, leading to their ultimate classification. In zoology this signifies a review of the essential features of all the forms studied and a grouping of the facts that will render plain the resemblances, differences and essentials requisite to distinguish the various groups into which the animal kingdom is di-

vided. It presupposes a comprehensive view of the pupil's whole work, requiring the exercise of his powers of judgment to their fullest extent and forms the summation of his acquirements in the subject. The study of the interrelations of animals and of their adaptation to environment will call for the exercise of the highest imaginative faculties in inventing hypotheses, while the explanation and harmonizing of the data thus collected will give active employment to the reasoning faculties and furnish most valuable training in logic.

The teacher of zoology should always bear in mind that this subject is a branch of science, and in scope, interest and dignity quite the equal of physics, chemistry, astronomy, geology or any other scientific subject. There is too great a tendency among high school teachers to teach zoology as though it were merely concerned with certain interesting facts about animals, and to deprive it of all the disciplinary value which comes from hard study of the different parts of the subject, to lower the laboratory work to the plane of the simple nature study of the grammar school and to be satisfied with a few superficial observations on the motions of living specimens, like the swimming of a fish in an aquarium, the jumping of a grasshopper, the crawling of an earthworm and so on. These are valuable and desirable in their place, but the maintenance of interest by having the class watch living animals is neither the sole nor the chief end to be attained by the study of zoology. There is much knowledge to be gained by the dissection of dead specimens, knowledge absolutely essential if the pupil is to have any real understanding of the structure and relationships of the main groups of animals. Pupils may not always enjoy working on such material, but it must be done if satisfactory results are expected.

Zoology will never equal in culture and disciplinary value such subjects as physics and chemistry till teachers recognize that it consists, as much as these do, of a well organized body of principles, that its subject-matter is the whole animal kingdom (not simply the class of insects or whatever group the teacher and his pupil may think most interesting), and that there are certain theories pertaining to the science which are of great importance and with the principal points of which every high school graduate should be familiar. Among the zoologic principles which should be made plain by as much laboratory work as possible are these: the cellular structure of animal organisms; the development of all forms, except protozoa, from the egg; the recognizable types of structure which, though few in number, render possible a classification of groups in an ascending order and imply a unity, with variability, of animal organization; and the structural adaptation of the animal to its environment and mode of life.

Zoology, then, should be studied in all its phases, and it is a misconception of the subject to select a few forms, as the molluscs and insects, for extended study and to give the other and usually more important groups only superficial examination. If possible, every group should be studied from the protozoa to the vertebrates and their essential characters of structure, physiology, habit and distribution clearly brought out.

The discussion of the theory of evolution need no more be avoided in teaching zoology than the theory of gravitation or the wave theory of light in physics, or the atomic theory in chemistry. The latter are the very foundation of the subjects of physics and chemistry and they serve to correlate the various phenomena in these two sciences: so in zoology the theory of evolution is the guide in all researches and the light which makes clear a vast multitude of otherwise obscure and incomprehensible facts.

**Laboratory work.** Laboratory work should be the principal feature of the course in zoology and should occupy about two thirds of the time.

The laboratory period is a study period, pure and simple, and corresponds very closely to the time spent at home in the preparation of lessons in mathematics, history and languages, the principal difference being that in the laboratory the pupil studies under the direction of his teacher, while in the subjects mentioned, the method of study being one with which the pupil has been familiar since his earliest school days, he is left to work by himself. The laboratory exercises consist not in solving problems according to set rules, nor in memorizing vocabularies or historical facts, but rather in observation, in studying at first hand the structural and physiological characteristics and habits of an organism, in independent investigation guided by questions suggested by the teacher, or by the pupil himself, and answered by a study of the specimen. The prime object of laboratory study is to develop in the pupil the habit of drawing conclusions based on facts which he collects for himself, and to give him a sense of his own powers of observation and judgment and a feeling of self-reliance. Along with this goes training in expression by written descriptions and pictorial illustrations of what he has seen. Such work is time-consuming and must be conducted with deliberation.

**Laboratory equipment.** The conditions needed for laboratory work consist of a teacher, a pupil and a specimen. These are absolutely necessary; anything additional is largely of the nature of a luxury. It is entirely possible to do good laboratory work, in the truly scientific spirit, without a microscope or any dissecting implements. If, however, the work includes the study of the lowest organisms, of the internal organs of specimens and of their cellular structure, the pupil must be provided with the necessary tools. The most essential feature in the laboratory is a properly trained teacher.

**Microscope.** The low price of microscopes makes it possible for every laboratory to be provided with one or more. There are two ways in which a microscope can be used; one to make the pupils gape in wonder that the instrument makes things look so big, the other (and only legitimate use) to aid vision in quite the same sense that eye-glasses do. The microscope should always be used as a tool to render clear the structure of parts too small to be seen with the unaided eye. It should never be treated as a sacred object, to be handled only by a chosen and awe-struck few for the purpose of showing some of the wonders of creation, but should be used on any and every occasion when a clearer insight into the structure of parts is needed. The instrument should be easily accessible to the teacher at any moment, so that, by merely taking it from its case and slipping the specimen on the stage, the microscope instantly becomes available for use. The cases are now made so that the instrument with its eye-piece and objective all adjusted can be placed within the case and the latter locked without having to remove any of these parts, as was required by the old form of case. A microscope whose parts must be put together before it can be used is likely to be employed too seldom.

If only one microscope be available, a state of affairs that can be tolerated only in the smallest high schools, then it should be used to demonstrate structure to the pupils, and the latter ought frequently to have access to it for a longer study of the specimens. In the larger schools a sufficient number of instruments ought to be provided to permit the class to work in sections.

It is not intended to maintain that the course in zoology should be mainly or even largely on microscopic organisms or on the minute anatomy of larger forms, for, as a matter of fact, most of the work in any well planned course will be on specimens requiring no other optical aid than a magnifying glass. It is, however, insisted on that no course can be regarded as satisfactory unless the proper amount of time is devoted to the lower animals (protozoa, hydroids, etc.) whose study requires the microscope, and to the minute structure of the higher forms.

The manipulation of the compound microscope is so easily learned that there is no reason for accepting from any teacher the excuse that he does not know how to handle the instrument. Let him learn. The teacher of physics has to learn the manipulation of a great many pieces of apparatus; likewise the teachers of chemistry. High school pupils usually learn to adjust the parts of the microscope in half an hour or less. Their teacher surely ought to be able to do as much.

**Textbook.** It is desirable to use a textbook in connection with the laboratory work. It should not, however, be regarded as the principal object of study but as a connected account and birds-eye view of the whole subject and as a means of extending the pupil's knowledge along lines on which he entered in his laboratory work and which lack of time and the limitation of his present attainments prevent him from pursuing farther. If a textbook be used, it is thought desirable by some to confine the laboratory work to forms similar to but not identical with those described in the text. In addition, pupils should be encouraged to read such books as Darwin's *Formation of vegetable mould through the action of earthworms,* Huxley's *Crayfish, an introduction to the study of zoology,* Wallace's *Malay archipelago,* Belt's *Naturalist in Nicaragua* and Bates's *Naturalist on the Amazons.* From these and similar books the pupil will gain an insight into the method of work followed by these great naturalists. In recitations the principal topics for discussion should be the facts which the pupil has learned in the laboratory. This is to be supplemented, not superseded, by what the textbook and teacher tell him.

**Notes.** Full notes descriptive of everything studied in the laboratory should be kept. While, as regards penmanship, these may be made hastily by the pupil, while at his work, they should at the same time be clear and full. Nothing should be left to the memory. At the end of the course or as often as the teacher thinks best the notebook, carefully written in ink and with the descriptions prepared for inspection not only with reference to their scientific accuracy but also to their grammatical and rhetorical construction, should be submitted to the teacher for examination, and a certain percentage of the pupil's class standing should be based on his notes and drawings.

In some schools it is the custom, a most commendable one, to allow the pupil to offer one or more of his descriptions as part of his required work in English composition. A little cooperation between the teachers of zoology and of English will in most cases serve to strengthen the work of each.

**Drawings.** Drawings should be made of every specimen which is carefully studied. It is not so necessary to sketch specimens examined casually for the sake of superficial comparisons only. Make the drawings of sufficient size to render all parts distinct. They may be made with ink or a hard pencil (Faber's HHHH), each entire specimen being shown preferably on a separate card or sheet with the disarticulated parts, as wings and legs of insects, on an accompanying card. Uniformity in the size of the cards facilitates their handling and preservation. Every specimen, part and organ should be designated in the drawing by its name or by a letter, a key to the lettering being placed on the same page as the drawing. Shading is to be avoided unless the pupil has had sufficient instruction in drawing to enable him to shade properly. Diagrams are usually found to require less artistic skill than sketches and, at the same time, they show more plainly whether or not the pupil has a correct understanding of the proper position of parts.

**Dissection.** It is impossible to get a correct idea of the internal structure of animals, except such as are transparent, without resorting to dissection. Some pupils dislike such work, while others enjoy it greatly. Usually those who are at first adverse to it soon become interested, specially when they once grasp the idea of the relationship between the structure of parts and their functions. In whatever light the pupil regards this phase of the work, dissection must be practised, for in no other way can the arrangement and structure of the internal organs be learned, and, unless he studies these, the pupil's knowledge will be limited to the purely superficial structures, which usually are only the organs of motion, prehension and of special sense. The organs of breathing, digestion, circulation and reproduction are generally invisible without more or less dissection of the specimen. The same may be said of the nervous and muscular systems.

If the teacher desires, he may, of course, prepare the dissections himself for the class, but this results in depriving the pupils of a distinct idea of the actual relation of internal parts, to say nothing of most excellent training for the hand and eye. Whatever procedure is followed, however, the pupil ought to have an opportunity to examine the internal anatomy of at least one representative specimen from each of the branches of the animal kingdom, otherwise he will never clearly understand the gradations of structure shown in passing from the lower to the higher forms, nor the basis of any of the systems of classification nor the foundation on which rests the theory of evolution.

**Museum.** A highly important factor in zoologic teaching is the museum, and the most desirable form for a high school to possess is one in which are shown the structure and relationships, the life histories and the habits of the native fauna. It is not wise to attempt to collect only rarities, nor yet to assume the position that a museum can not be interesting unless it contains specimens of the ornithorhynchus, wingless birds, lung fishes and so on. It should not be made a catchall for various monstrosities and moth-eaten specimens of the taxidermist's art of which careful housekeepers may like to be rid. A good museum is a gradual growth, and its material is likely to be most highly prized and to have the greatest pedagogic value and interest if collected by the pupils themselves. The boy whose father keeps bees can readily supply a collection showing the various stages in the construction of the comb, together with a set of specimens showing the development of the insect from the egg to the winged stage, and a sample each of worker, drone and queen. Others can bring in the various nests of wasps and leaf-cutter bees. Many insect pests of the orchard and field, with samples of their ravages, are everywhere to be found. The changes from caterpillar to moth and butterfly, with eggs and food plant, are easily observed. The museum might also contain specimens showing the development of the mosquito, may-fly and dragon-fly and numerous other water insects; cocoons and adult earthworms; eggs, tadpoles and adult frogs and toads; snakes and turtles with their eggs; the nests of birds arranged according to the building materials used, the ingenuity of construction, etc.; a set of skins of native birds, as well as a set of eggs, to be used in identifying those seen in the neighborhood. Another valuable feature of the museum would be a collection of crude and manufactured animal products to illustrate economic zoology, e. g. cochineal insects and sample of carmine, cantharides, useful articles of bone, nacre, shagreen, ivory, etc.

If large museums are accessible, as in cities, much valuable work can be done by pupils guided by questions or by outlines of study previously prepared by the teacher. A natural history museum can thus be made an indispensable aid to the city schools. Visits to the public markets, specially in large cities, are very instructive.

**Field work.** In order to supply material for the museum and for class work, and particularly to enable pupils to see the various animals in their natural surroundings, frequent collecting trips should be made either with the entire class or, if this be impracticable, with sections. The collecting instinct, however, should not be too much encouraged, for it leads to a wanton destruction of living things. It is far better to cultivate a taste for watching animals quietly to see how they behave when unmolested. If the pupil has one bird to dissect, so that he may learn its anatomy, and a named collection of skins, from which he can learn to identify at a distance nearly all of the birds he is likely to see in his rambles, it is useless, in fact highly undesirable, to provide him with a gun with which to shoot at every bird and mammal he comes across. One great object to be borne in mind in teaching zoology is to cultivate a sense of sympathy and respect for the lower animals. Field excursions should be taken with a view to solve some definite problems rather than for the mere sake of random observations, though part of the time may profitably be thus used.

But whether or not field excursions and visits to museums are made, the pupil should learn to know the animals which he sees on his way to and from school, in his own block and yard and those which live about and in the house. The structure and habits of domestic animals and household pets, of rats and mice, of swallows, robbins and sparrows, of ants, bees, flies, mosquitoes and spiders, of earthworms and the "thousand legs" are legitimate, proper and interesting topics of study, and the pupil's knowledge of these should be more accurate and intimate than of kangaroos, polar bears and gorillas. Interest may be easily awakened in economic zoology, specially entomology, and pupils will soon come to have an intelligent appreciation of the work of the state and national governments in this direction.

**Aquarium and vivarium study.** Other useful and most important adjuncts are the aquarium and the vivarium. The former may be merely a fruit jar or large bottle if nothing better can be procured, but the regular article is naturally to be preferred. If possible several aquariums should be kept in operation throughout the school year, and in them can be watched the movements, mode of feeding and breathing of numerous species of fresh-water snails, as well as the mussels. The larvae of caddis flies with their curious cases, of dragon-flies, may-flies, mosquitoes, together with many species of water worms and insects, the green and brown hydras, crayfishes, tadpoles and young frogs, toads and small fishes of various kinds may all be kept in aquariums, and their habits and development studied. Specimens of these animals are most interesting and instructive to have in the schoolroom. Small aquariums are easily kept at home and pupils should be encouraged to stock them and to report their observations in the form of essays read before the class.

Vivariums may be merely wooden boxes whose tight bottoms are covered with sand and moss, or, preferably, such boxes with glass sides. In them may be kept for some time such insects as grasshoppers and crickets, and the larvae of various beetles, butterflies and moths. Earthworms, snails, slugs, newts, frogs, toads, snakes and turtles usually live a long time in such quarters provided they are kept clean and moist, and have an abundance of fresh air without too strong sunlight.

An admirable way to use the aquarium and vivarium is to lay by the side of it for a day or two a definite written or printed question referring to some particular habit, action, or structure of *one* of the inhabitants. After this question has been answered by the pupils another may be proposed. In this way each receptacle becomes an almost inexhaustible storehouse of interesting facts. Unless their attention is thus directed to particular objects, pupils are likely to regard both aquarium and vivarium with listless curiosity.

**Technical terms.** The use of the more important technical terms should not be avoided simply for the sake of making the subject easier. Such terms in any branch of human knowledge whether a science or not, are always very limited in their significance, and their proper application and use show that the pupil has a clear and definite understanding of the topic under discussion. They form a legitimate part of the study of mathematics and of grammar, and there is no reason why they should not be used in zoology as well as in the other sciences. They increase the pupil's vocabulary, correct looseness of speech and give training in clearness and accuracy of expression. When being learned their derivation and application ought always to be thoroughly explained. It is not to be inferred from this that the memorizing of scientific terms is to be the important feature of the course. The teacher must use his discretion in determining which terms are to be learned, and, if he applies them properly himself, the pupils will learn them as readily as they will the names of new characters in history or fiction, or new words in English, German, Latin, French or Greek. An object to be avoided is to humor the pupil in the feeling that, since a term is scientific, it is, therefore, necessarily difficult to pronounce and to understand.

**Classification.** Except in its broadest outlines the high school pupil should not be expected to be familiar with classification. He ought to know the structural characteristics of the great branches of the animal kingdom and the names of these branches, but it is questionable whether his knowledge should extend beyond the most important three or four classes in each branch except in the class mammalia, where he should be familiar with the principal orders. If a representative of each branch be given him to study and dissect, he will learn almost unconsciously the important structural features of the branches, and this knowledge will form a firm basis for the superstructure of classification, but the idea can not be too strongly emphasized that the business of the high school teacher and pupil is not primarily to discuss systems of classification but rather to confine their attention to structure and habits. Classification requires for its comprehension and appreciation many years of special study of the subject and is not suited to the capacity and equipment of the high school pupil. Teachers who spend their time in having their classes memorize and recite the taxonomic characters of the various groups of animals are following a vicious method which deprives the pupil of training and knowledge to which he is entitled.

**Time.** In order to receive the attention which its importance warrants zoology ought to be given for a period of at least 20 weeks with daily exercises.

The time of year during which the subject is taught must be determined very largely by the special environment of each school. The teacher in a city high school may find that it is inexpedient to do much, if any, field work with his class and will have to depend on aquariums and vivariums instead. These are most easily stocked in the fall, but many specimens are likely to die during the winter. In such cases it may be deemed preferable to give the course during the first part of the school year. On the other hand, the teacher who has opportunities for excursions will, undoubtedly, want to begin the course during the latter half of the school year, and thus be enabled to make use of the numerous developing forms, as frogs and insects, to be found in the spring.

**Course of study.** For a course in zoology extending throughout the year with daily exercises, it is recommended that the following types be studied, in the living condition, when possible, and by dissection when the forms are large enough for this purpose: amoeba, paramoecium, hydra, starfish, sea-urchin, earthworm, trichina or tapeworm, crayfish or lobster, spider, grasshopper, butterfly, mussel, snail, fish, frog or toad, turtle, bird, cat or rabbit.

If the course extend through only 20 weeks with daily exercises, the following forms may be taken as representing the chief types of structure: amoeba, hydra, starfish, earthworm, crayfish or lobster, grasshopper, mussel, fish, frog, turtle, bird, cat or rabbit. If a smaller amount of laboratory work be done, it is suggested that only two vertebrates, for example, frog and mammal, be studied in addition to the invertebrates.

It is by no means necessary to study the types given in either course in the order given. Some of the teachers may prefer to begin with an intermediate group, as the insects, work upward through the vertebrates, and then deal with the lower forms from amoeba to grasshopper. The principal arguments usually presented in favor of this plan are that the pupil then follows the sound pedagogic principle of proceeding from the known to the unknown, and that, being unfamiliar with the use of the microscope, he ought not to be set to study an unknown specimen with an instrument to which he is not accustomed. To these objections teachers who believe in pursuing the study of the types in logical order by passing from the simplest to the more complicated organisms, reply first, that, while most pupils have seen grasshoppers flying about, they are actually no more familiar with the structure of the insects than with that of amoeba and the dictum " from the known to the unknown " is no more applicable in the one case than in the other; secondly, that, no matter at what period in his course the pupil begins to use the microscope, the instrument will always be unfamiliar to him till he actually commences to use it, hence, he may as well begin at once as later and pursue the study of animal structure in the logical manner, the manner which provides him with the principal data for the classification of animals and which also reveals to him the fundamental facts of evolution. The first weeks of the fall term are specially good for field work with insects, which may be considered an important practical reason for beginning the study with this group.

If two terms are available for the work, the invertebrates may be studied during the first and the vertebrates during the second term.

Whatever may be the length of time allowed for the subject, it is hardly desirable to carry the study of structure to such minute details as, for example, tracing the course of the smaller blood-vessels and nerves in vertebrates or dissecting out the less important muscles. It is better for the pupil to get thoroughly in mind the arrangement and position of the principal members of the various systems, nervous, digestive, circulatory, respiratory, secretory and reproductive than to study the minutiae of any one of these sets of organs. In vertebrate structure the principal stress should be laid on the increasing complexity of these systems as seen in passing from the lower to the higher forms.

### Outline of practical work in zoology

The following syllabus forms an outline of study covering the year's course mentioned above. It is capable of considerable modification to suit equipment for laboratory work, the special preparation of the teacher, and the preliminary training of the pupil. The features mentioned are those to which it is desirable to direct the attention of the pupil. The amount of time to be spent in the study of each topic or structure must be largely determined by the teacher, as the syllabus can only indicate the ground which ought to be covered. The 20 weeks course consists of the study of the smaller number of types already mentioned. The outlines of study for these types are printed in the syllabus in the larger type. Detailed directions for the dissection of the various specimens will be found in the laboratory manuals mentioned on p. 771.

It is to be understood that drawings are to be made of all structures examined and that a careful description of the habits and structure of each specimen is to be written.

The economic importance of the specimen should always receive attention.

## *Invertebrates*

### PROTOZOA

*Amoeba*. Material — Found by rinsing damp moss, specially sphagnum, in a small amount of water; in the scum on the under side of floating lily pads or on the stems of water plants; in the sediment in the bottom of aquarium jars in which algae are growing.

Microscopic study — Under the lower power of the microscope, (two thirds inch objective) watch the mode of progression by the protrusion of portions of the body substance (protoplasm), thus forming the *pseudopodia*. Note the ceaseless change of shape which this mode of locomotion entails. With the same or a higher power (one fourth inch or one sixth inch objective) examine the structure of the animal, noting the clear, outer layer of protoplasm shading imperceptibly into the central, more granular portion. In the latter look for the nucleus and the contractile vacuole, the distinctive characters. Notice the various food particles embedded in the protoplasm, usually diatoms, fragments of algae, particles of plant tissues, etc. Note how the food is ingested, refuse passed out; the rate of movement of the contractile vacuole.

Some of the "shelled" forms like *Arcella or Difflugia* may be used for comparison.

*Paramecium*. Material — Cultivated in abundance in a dish of water in which chopped hay, preferably marsh grass, has been standing for two or three weeks. Cultures may be hastened by using water from a ditch receiving house drainage, particularly if some of the black slimy ooze from the bottom of the ditch be added. An excellent and usually successful method is to allow some of the weeds from such a ditch to decay in a dish of drainage water.

Aquarium study — In the culture note the swarms of animalcules, their position with reference to the surface of the water, the sides of the dish, the direction of the brightest light; their size, color and movements.

Microscopic study — Under the low power study their motions; position with reference to air bubbles, edge of cover glass and masses of nutriment (usually clumps of bacteria); shape. Under the high power examine their structure, the cuticle or cell wall, the numerous cilia, the food vacuoles, the contractile vacuoles, the position and shape of the nucleus (using a stained specimen if necessary). Look for the mouth. Note their sensitiveness to contact, the various motions of the body, the movements of the cilia and vacuoles, the ingestion of food particles, the ejection of waste. Look for specimens undergoing division, or in the process of conjugation.

Attention should be called to the possible means of dispersal of the animal, to its value as a scavenger and particularly to the "physiological division of labor" among the various portions of its body, which, though a single cell, has its party very plainly adapted to perform many different functions.

For comparison, *Vorticella*, *Stentor*, or *Stylonychia* may be used.

## METAZOA

### Coelenterata

*Hydra*. Material — Either the green or the brown species may be used; the latter, being much the larger, is preferable. It will be found attached to the stems of water plants which may be kept in aquarium jars. The animals will often migrate to the sides of the jar, where they can be studied with or without a lens. The green species is common on species of *Vaucheria* or greenfelt, which grow in rapidly flowing creeks. Mats of the plant may be put into white earthenware dishes. After a few minutes the hydras will expand and be easily seen against the background formed by the dish.

Aquarium study — With the naked eye or with a lens study the hydra in situ, noting its color, shape, size, the body and the tentacles, the number and extensibility of the latter; touch the body or the tentacles with a bristle and note the sensitiveness of the animal. Look for individuals bearing buds; the number and position of the latter; the radial symmetry of the body. Note how well the shape and color of the animal adapt it to its surroundings.

Microscopic study — Transfer a fragment of the plant bearing a hydra to a watch glass (or, if the animal is fastened to the side of the jar, detach it with a pipette) and examine under a lens or under a low power. Note again the movements of the body and tentacles. Put a minute fragment of fresh meat within reach of the tentacles and endeavor to see the hydra catch and swallow it. Study the movements of the mouth.

Mount a specimen under a cover glass and study the structure of the body, its walls consisting of two layers of cells; the central cavity with one exterior opening; the color of the inner cell-layer and its cause; the structure of the tentacles, the groups of nettle-cells; cause the discharge of the latter by running a drop of weak acetic acid under the cover glass. On individuals bearing buds study the structure and actions of the latter; their mode of attachment to the parent; the small "colony" formed by this mode of reproduction.

Note the effect of light on hydras by putting several in a jar of water and covering it with an opaque paper through which on one side a hole one inch in diameter has been made, the jar then being placed near a window and the hole being directed toward the light.

The colonial, marine hydroids, like *Eucope, Pennaria* or *Eudendrium*, may be used for comparison.

### Echinodermata

*Starfish.* Aquarium study — If live specimens can be obtained, study their mode of locomotion; the flexibility of the rays and the body; the movement of the spines along the grooves, around the mouth opening and at the tip of the ray where the eye is located; note the sensitiveness of the various parts, particularly of the tube-feet and of the branchiae; note also that the numerous tube-feet move as though regulated or coordinated by some governing power, their movements being thus directed toward the attainment of some definite end instead of being at random. Examine a number of specimens and look for variations in the size of the rays. These will show the power of regenerating lost parts, which the starfish possesses to a high degree.

Structure — Study the position and arrangement of all external parts, the spines, tube-feet, eyes, branchiae, madreporic body, peristome, the radial nerve in the roof of each groove. Remove the upper half of the outer "shell" and note the internal organs; the digestive system consisting of the stomach and digestive glands; the internal parts of the water-vascular system, the water-sacs and the "stone canal"; the reproductive glands; note the radial plan of structure.

Exhibit a series of eggs showing different stages of segmentation, also the larval forms of the starfish.

*Sea-urchin.* Aquarium study — Note its mode of locomotion, its sensitiveness, its movements in righting itself after having been turned bottom side up.

Structure — Trace all the resemblances you can between its external structure and that of the starfish. Note that in spite of their difference in shape their likeness in structure is very marked. Study the digestive system, the teeth and the long intestine. Note the radial symmetry.

Exhibit the larval stages.

The cake-urchin (*Echinarachnius*) and the holothurian (*Holothuria* or *Synapta*) may be used for comparison. No other group of animals shows so well as the echinoderms that the same plan of structure may be associated with the greatest diversity of external form.

### Vermes

*Earthworm.* Field or vivarium study — Study living specimens out of doors, note their castings along paths, the amount of earth brought up; the diameter of the burrows, trace the latter down into the soil. Place a live worm on the surface of the soil and note its mode of locomotion; its method of burrowing; the protection from enemies afforded by its color; draw one out of its burrow and note the resistance; touch a worm with a bristle and note its sensitiveness; note the effect of plugging the mouth of the burrow with bits of straw, leaves, etc.

Watch the pulsations of the dorsal blood vessel.

Structure — Note the shape of the body, the rings composing it, the girdle, the mouth, the anus, the openings of the reproductive glands, the bristles.

Cut an alcoholic or formalin specimen open along the middle of the back and examine the muscular wall of the body; the tough, transparent cuticle; the alimentary tube within with the blood vessel and digestive gland on its upper side; the partitions connecting the digestive tube with the body wall; the long series of cavities nearly separated from one another by these partitions, the whole forming the body cavity; the continuous digestive canal opening at each end to the exterior; the pair of excretory organs in each separate cavity. Study the digestive tube consisting of pharynx, oesophagus, crop, gizzard and intestine; note the structure of the wall of the tube in each of these regions; the supra-oesophageal ganglion or "brain" lying above the pharynx; the nerve-cord below the alimentary canal; the reproductive glands along the anterior part of the canal; note the bilateral arrangement of all organs; also that the principal parts of the circulatory system lie above and of the nervous system below the digestive system.

Draw attention to the economic and geologic importance of the earthworm in overturning the soil as it feeds and constructs its burrows. If cocoons can be found (often attached to straws around manure heaps) examine the various stages of development of the earthworm.

*Tapeworm, or trichina.* Material — Alcoholic specimens of the former and microscopic preparations of the latter may be studied and attention called to their complicated developmental history, and their pathologic significance.

With these forms of "worms" may be compared the *Leech* and *Nereis.*

### **Arthropoda**

#### 1 Crustacea

*Crayfish or lobster.* Material — Live specimens of the former may be kept indefinitely in aquarium jars containing algae and supplied at intervals with a few crumbs or fragments of beef or fish.

Aquarium study — Watch their movements when walking and swimming; the various motions of which the legs are capable; the movements of the antennae, eyes and swimmerets; the position of the abdomen; the manner in which food (a scrap of fresh beef) is held and pieces put into the mouth; the movements of the jaws; of the breathing organs; the position of the eggs, if a female " in berry " can be obtained; the means of offense and defense.

Structure — With a dead specimen, preferably alcoholic, note the hard covering of the body; the two regions (cephalothorax and abdomen); the rings or segments of which the latter is composed; the membranous parts between adjacent rings; the indications of segmentation seen on the under side of the cephalothorax; the number and structure of jointed appendages on the abdomen; the use of each kind; the number, structure and use of the locomotor appendages on the cephalothorax; the specialization of each pair for particular functions; the relation between legs and gills; the arrangement, structure and use of the various mouth parts; the structure of the eyes and " feelers "; the ear; the protection of the gills; endeavor to make out the fundamental plan of structure which underlies the great diversity of form shown by the various appendages.

Cut through the shell along each side and remove the upper part, thus exposing the internal organs. Note the large muscles in the abdomen; the pericardium and heart with the large artery running backward along the middle line of the large abdominal muscle; the stomach with the bonelike parts in its walls; the intestine; the digestive glands; the oesophagus; the reproductive glands; the " green glands " (in the crayfish); the nerve-cord lying below the digestive system; the "brain"; note the tendency of ganglia to fuse into larger nerve centers.

Exhibit a series of larval crayfishes or lobsters showing the changes undergone at each molting.

Try to get specimens of the lobster showing the regeneration of lost parts, specially the pincers.

Call attention to resemblances in structure between earthworm and crayfish; note in the latter the tendency to collect into definite regions the organs devoted to definite uses; also the tendency to collect sense organs into a definite "head region"; also that every segment bears a pair of jointed appendages.

Use the crab (*Callinectes*) for comparison.

### 2 Arachnoidea

*Spider.* Field and vivarium study — Study the mode of locomotion; the position, arrangement and captured contents of a web; the position of the spider in the web. Put a spider into a large pasteboard or wooden box, cover with a sheet of glass and note how the silk is spun and the web is constructed. Look for cocoons and study their structures and contents.

Structure — Note the same regions as in the crayfish (cephalothorax and abdomen); study the points of resemblance and of difference; indications of segmentation shown by each; compare the number, position and structure of the legs; study the spinnerets, their position, number and form; the mouth parts; the eyes; the structure and appendages of the skin; the openings of the breathing chambers.

Dissect alcoholic specimens in a dish of weak alcohol or of water and note the arrangement of the digestive and nervous systems.

### 3 Insecta

*Grasshopper.* Living specimens may be kept in boxes or jars covered with gauze or netting and kept supplied with plenty of fresh grass or wheat.

Field and vivarium study — Note how the insect walks, leaps and flies; the length of a single leap; how the food is held and eaten; the use of the various sense organs, as eyes and feelers; the mode of breathing; the protective coloration of the body.

Structure — Note the three regions of the body (head, thorax and abdomen), comparing with crayfish and spider; study the structure of each region; the appendages borne by each region;

their use; the structure of each kind of appendage and its adaptation to its special function; the spiracles; the ovipositor on the female; the ear.

Cut open a specimen lengthwise and note the parts of the digestive system; the muscles; the reproductive organs; the structure and arrangement of the nervous system. Examine tracheal tubes with the microscope.

Compare the plan of structure of the grasshopper with that of the earthworm, crayfish and spider.

Try to get young grasshoppers and note the changes which are shown at the successive molts.

*Butterfly.* Field and vivarium study — Note its wavering flight, the way it walks, the position of the wings, when at rest, the use of the proboscis when gathering nectar, the species of plants visited, the position of the proboscis when not in use.

Structure — Note the similarity of structure to the grasshopper; the differences between the wings of the insects; the greater uniformity in the structure of the legs of the butterfly; the position of the eyes; the shape of the antennae; the structure of the proboscis; the microscopic appearance of the scales on the surface of the wings.

Examine the larva, noting its shape and color; its mode of locomotion; locomotor organs; food and method of feeding.

Study the chrysalis and eggs, if obtainable.

The bee, fly and beetle may be used for comparison.

### Mollusca

*Mussel.* The river mussels may be kept in aquariums having two to four inches of sand or mud on the bottom.

Aquarium study — Study the movements of the animal; the opening and closing of the shell; the position and use of the foot; of the siphons; the sensitiveness of the siphonal tentacles; the incurrent and excurrent streams of water.

Structure — Examine a shell noting the two similar valves; the hinge and hinge-ligament; the hinge-teeth (if present); the "epidermis", lines of growth and nacre; the scars left by the muscles.

Examine the soft part of the body, the mantle lobes; the gills; the body and the foot; the palpi and the mouth; the anal opening; the adductor, protractor and retractor muscles.

Cut the body through lengthwise and trace the course of the alimentary canal. Endeavor to trace the parts of the nervous system; the cerebral and the visceral ganglia; the heart; the digestive gland. Make three or four cross sections from a specimen hardened in formalin or alcohol and study supra-branchial canal, gills, etc.

Examine the gills for eggs and young.

*Land or water snail.* Field or aquarium study — Study its movements; its mode of respiration; its feeding; the movements of the "rasp"; the use of the feelers; the manner in which the body is protruded from the shell and retracted.

Structure — Compare its shell with that of the mussel. Note the whorls; the lines of growth; the attachment of the body to the shell.

Remove the soft parts and study their structure, the digestive system; the large liver; the heart; the brain and nervous system.

Note that the bodies of both these mollusks are unsegmented and are without appendages.

Snails kept in aquariums frequently attach their eggs to the sides of the jar or to water plants. The segmentation of the egg and the development of the larva may be studied with a low power or with a hand lens.

### *Vertebrates*

*Fish.* Aquarium study — Study living specimens in the aquarium, their movements of locomotion and of the various fins; mouth, gill-covers and gills; the eyes; the method of feeding and of respiration; the distribution of colored spots on the body; the adaptation of shape to locomotion in the water; test the use of each fin by binding them separately to the body by means of rubber bands slipped on over the fish's head.

Structure — On a dead specimen note the bilateral symmetry; the head; the absence of a neck; the body and scales; the position and structure of the fins; the shape and structure of the mouth; the teeth; nostrils; tongue; gills; the lateral line; microscopic structure of scales and gills.

Dissect away the skin from one side and study the arrangement of the muscles.

Cut open a specimen and study the position and relation of the internal organs; the peritoneum; the digestive, circulatory and reproductive systems; the structure of the heart; open the skull and examine the brain and the principal nerves arising from it. Remove, by boiling, the flesh from the skeleton and study the structure of the latter.

Make a microscopic examination of the blood.

Obtain (from one of the state hatcheries, if necessary) a series of living eggs and embryos and study the development of the fish.

If opportunity offers, a visit to a fish market may be made and an examination made of the various kinds of food fishes.

*Frog.* Vivarium and aquarium study — Keep live specimens in aquarium jars or in boxes containing damp moss. Study the manner in which the frog creeps, leaps, swims, breathes, moves and closes its eyes, catches flies; the position of the body at rest; with a thermometer try to get the natural temperature of the body.

Structure — In a recently killed specimen note the color and structure of the skin, the position of eyes, ears, nostrils, lips, the position and arrangement of the lips and the teeth, the shape and mode of attachment of the tongue; the sticky saliva and its use; the absence of a neck.

Dissect away the skin and study the shape and attachments of the underlying muscles. Open the abdomen and study the arrangement of the internal organs, the digestive, circulatory, respiratory, excretory and reproductive systems; the structure of the heart. Open the skull and examine the brain; trace the course of the principal nerves. Study the principal parts of the skeletal system and compare with that of the fish. Examine the circulation of the blood as seen in the web of the foot. Study the corpuscles in a drop of fresh blood.

Collect the eggs of frogs or toads in the spring, keep them in an aquarium and watch the development of the tadpole. Have a series of tadpoles showing the gradual metamorphosis into the adult stage.

Draw attention to the changes of structural adaptation necessitated by the change from the aquatic to the aerial mode of life.

*Turtle.* Water or land turtles may be used and may be kept in the laboratory in a damp box for a long time without apparent discomfort.

Field, vivarium and aquarium study — On some of the field excursions look for turtles in their native haunts and learn as much as possible of their habits. In the laboratory note how the turtle walks, its clumsy motions, rate of speed; the motions of and positions taken by its head, legs, tail; movements of the eyelids, nostrils; the respiratory movements. Put the turtle into water and watch its movements when swimming and diving.

Structure — Study the external covering, its structure, color and modifications on the body, head, legs and tail; compare with fish and frog; the head, its shape and various parts composing it, the jaws, eyes, nostrils; note the absence of teeth; the tongue.

Remove the lower half of the shell and study the internal organs composing the digestive, circulatory, reproductive and excretory systems; compare the structure of the heart with that of the fish and the frog.

On a skeleton note the various parts which are attached to the shell; the skull and neck; the hyoid apparatus, the structure of the limbs and tail; compare the hyoid apparatus and the ribs with those of the frog.

If eggs can be obtained, note the shape, structure of the shell, and the stages of development of the young.

*Bird.* Sparrows or pigeons may be used.

Field study — Note its general mode of life, whether solitary or gregarious; relations to other birds and to man; its manner of flight and of walking; feeding habits; size, shape and coloration of the body; variations in coloration at different seasons of the year; position and structure of the nest, number, shape, size and color of eggs, number of broods each year, season when broods are produced, and number of young in each brood; enemies; song; if a living specimen can be obtained, test the body temperature with a thermometer.

Structure — With a recently killed specimen, study the shape of the body, the direction of its axis; the position and mobility of the head, wings, legs and tail; the distribution of the various feathers, their structure. Remove the latter and note the feather tracts and the skin. Study the shape and structure of the head, the beak, eyes, nostrils and ears; compare with the turtle. Examine the wings and legs, noting the direction and movements of the various segments; the structure and movements of the parts of the foot; the position of the principal muscles; their uses.

Open the body and study the digestive, circulatory, respiratory and reproductive systems; the air spaces among the muscles; the structure of the heart and brain as compared with the vertebrates previously studied; the microscopic appearance of the blood corpuscles.

Prepare or purchase a skeleton and study the arrangement of its various parts and the structure of the different bones, comparing with the fish, frog and turtle.

Study the structure of the egg and the development of the young (a convenient and satisfactory substitute is the hen's egg).

Draw attention to the economic value of the bird studied.

**Mammal.** The cat or rabbit may be used.

*Laboratory study.* Study the motions of the animal as it walks, runs, leaps, its position when at rest; food and mode of feeding; respiratory movements; motions of head, legs, tail, ears, eyes; mode of cleaning its fur; body temperature; protective coloration.

Structure — On a recently killed specimen note the general shape of the body and direction of its axis; the position and mode of attachment of the appendages; the hairy covering, the groups of specialized hairs in certain positions, the microscopic appearance of hair; the mobility of the skin; its firmer attachment in certain places, compare with the external covering of fish, frog, turtle and bird. Study the shape and structure of the head, the position and structure of ears, eyes, nostrils and mouth.

Remove the skin from the body and study the position and attachment of the more important muscles, their uses. Open the body and examine the organs composing the digestive, circulatory, respiratory, excretory and reproductive systems. Note the position and structure of the teeth and their fitness to masticate the special kind of food the animal eats; the surface of the tongue and its adaptation as an organ for cleaning the fur; compare the heart and brain and the microscopic appearance of the blood corpuscles with those of other vertebrates examined.

Trace the course of some of the principal blood vessels and nerves.

Examine a skeleton and compare with that of the other vertebrates studied.

A series of preparations of fetal kittens or rabbits may be examined.

## Helpful books for teacher and pupil

### INTRODUCTORY AND GENERAL

Cooper. Animal life in the sea and on the land. American bk co., New York $1.25

Furneaux. Life in ponds and streams, 1896. Longmans, New York $2.50

Houssay. Industries of animals, 1893. Scribner's Sons, New York $1.25

Huxley. Introduction to the study of zoology, illustrated by the crayfish, 1895. Appleton (International scientific series) New York $1.75

Hyatt. Guides for science teaching, including Commercial and other sponges, 20¢; First lesson in natural history (Mrs Agassiz), 25¢; Common hydroids, corals and echinoderms, 20¢; Oyster, clam and other molluscs, 20¢; Worms and crustacea, 25¢; Insecta, $1, 1883–90. Heath, Boston, Mass.

Parker. Lessons in elementary biology. 3d ed. Macmillan, New York $2.65

Sedgwick and Wilson. Introduction to general biology, 1895. 2d ed. Holt, New York $1.75

Thomson. Study of animal life, 1896, 3d ed. Scribner, New York $1.25

LABORATORY MANUALS AND GUIDES TO PRACTICAL WORK

Brooks. Handbook of invertebrate zoology, 1894. Cassino, Boston, Mass. $3

Colton. Elementary course in practical zoology, 1889. Heath, Boston, Mass. 80¢

Dodge. Introduction to elementary practical biology, 1896. Harper, New York $1.80

Gorham and Tower. Laboratory guide for the dissection of the cat, 1895. Scribner's Sons, New York

Howes. Atlas of practical elementary biology, 1885. Macmillan, London $4

Huxley and Martin. Course of elementary instruction in practical biology, revised ed., 1889. Macmillan, New York $2.60

Jordan. Manual of the vertebrate animals of the northern United States. 8th ed. McClurg, Chicago $2.50

Marshall and Hurst. Junior course in practical zoology, 5th ed. 1899. Smith, Elder Co., London $3.25

Martin and Moale. Handbook of vertebrate dissection; turtle, pigeon and rat, 3 v., 1881-83. Macmillan, New York; v. 1 and 2, 75¢ each; v. 3, 60¢

Needham. Elementary lessons in zoology, 1895. American bk co., New York 90¢

Parker. Course of instruction in zootomy, 1884. Macmillan, London $2.25

Wilder and Gage. Anatomical technology, 1886. 3d ed. Barnes, New York $3.60

TEXTBOOKS

Kingsley. Elements of comparative zoology, 1897. Holt, New York $1.20

McMurrich. Invertebrate morphology. Holt, New York $4

**Orton.** Comparative zoology, revised ed. Harper, New York $1.80

**Parker and Haswell.** Textbook of zoology, 2 v., 1897. Macmillan, New York $9

**Thomson.** Outlines of zoology, 1899. 3d ed. Appleton, New York $3.50

**Wiedersheim.** Comparative anatomy of vertebrates, new ed., 1898. Macmillan, New York $3.25

### THEORETIC

**Binet.** Psychic life of the micro-organisms. Open court publishing co., Chicago 75¢

**Darwin.** Origin of species by means of natural selection, new ed., 1883. Appleton, New York $2

**Marshall.** Lectures on Darwinian theory, 1894. Macmillan, New York $2.25

**Morgan.** Animal life and intelligence, 1891. Ginn, Boston $4

**Romanes.** Scientific evidences of organic evolution. Macmillan, New York 50¢

—— Darwin and after Darwin, 1, The Darwinian theory. Open court publishing co., Chicago $2

**Salt.** Animals' rights, 1894. Macmillan, New York 75¢

**Wallace.** Darwinism, 1891. Macmillan, New York $1.75

### TRAVELS AND OUTDOOR STUDIES

**Bates.** Naturalist on the river Amazon, 2 v., 1892, new ed. London

**Belt.** Naturalist in Nicaragua, 1888, new ed.

**Darwin.** Naturalist's voyage around the world, 1884, revised ed. Appleton, New York $2

**Gibson.** Sharp eyes, 1892. Harper, New York $2.50

—— My studio neighbors, 1898. Harper, New York $2.50

—— Eye spy, 1898. Harper, New York $2.50

**Hudson.** The naturalist in La Plata, 1892. Chapman & Hall, London $4

White. Natural history of Selborne. Warne & Co., New York $1.25

### SPECIAL BOOKS

Blanchan. Bird neighbors, 1898. Doubleday, New York $2

Chapman. Bird life, 1898. Appleton (colored edition), New York $5

Comstock. Manual for the study of insects, 1895. Comstock pub. co., Ithaca, N. Y. $3.75

—— Insect life, 1897. Appleton, New York $2.50.

Felt. Collection, preservation and distribution of New York insects, Bull. N. Y. S. museum, no. 26, v. 6, Ap. 1899

—— Shade tree pests in New York state, Bull. N. Y. S. museum, no. 27, v. 6, May 1899

Holland. The butterfly book, 1898. Doubleday, New York $3

Lubbock. Ants, bees and wasps, 1882. Appleton (International sci. ser.) New York $2

Marshall. The frog, 1888, 3d ed. Smith, Elder & Co., London

Merriam. Mammals of the Adirondack region, 2 v., 1882–84. New York

—— & Denny. Structure and life history of the cockroach, 1886. Reeve & Co., London $2.75

Miall. Natural history of aquatic insects, 1895, Macmillan, New York $1.50

Miller. Preliminary list of the mammals of New York, Bull. N. Y. S. museum, no. 29, v. 6, Oct. 1899

Packard. Textbook of entomology, 1898. Macmillan, New York $4.50

Romanes. Jellyfish, starfish and sea-urchin, 1885 (International sci. ser.) New York $1.75

Scudder. Guide to the butterflies, 1893. Holt, New York $1.10

Scudder. Life of a butterfly, 1893. Holt, New York 90¢

Smith. Economic entomology, 1896. Lippincott, Philadelphia $2.50

Weed. Life histories of American insects, 1897. Macmillan, New York $1.50

### GOVERNMENT REPORTS

Allen. Monograph of the bats of North America. Smithsonian miscellaneous collections

Binney. Land and fresh-water shells of North America, 3 pt. Smithsonian miscellaneous collections

—— Manual of American land shells, U. S. national museum bulletin no. 28, 1885. Washington

Cope. Batrachia of North America, U. S. national museum bulletin no 34, 1889. Washington

DeSaussure. Hymenoptera of North America, solitary wasps. Smithsonian miscellaneous collections

—— and Bean. Oceanic ichthyology,. 1895, U. S. national museum bulletin (special)

Goode. Fishery industries of the United States. Washington

Jordan. Report of fur seal fisheries, 4 pt. 1898. Washington

—— and Evermann. Fishes of North and middle America, 3 pt. U. S. national museum bulletin no. 47

Merriam and Barrows. The English sparrow in North America

Merriam and Fisher. Hawks and owls of the United States in their relation to agriculture, 1893. Dep't of agriculture, Washington, D. C.

Osten-Sacker. Monograph of the diptera of North America. Smithsonian miscellaneous collections

Tryon. Land and fresh-water shells of North America. Smithsonian miscellaneous collections

U. S. entomological commission, five reports, 1878–90, Washington

In *Bulletin* 39 U. S. national museum are directions for collecting specimens as follows.

Birds (Ridgway); preparation of rough skeletons (Lucas); birds' eggs and nests (Bendire); reptiles and batrachians (Steinger); insects (Riley); molluscs (Dall); marine invertebrates (Lo Bianco); small mammals (Miller)

### LABORATORY SUPPLY

Microscopes, dissecting instruments, reagents, models, charts, etc.

Bausch & Lomb optical co., Rochester and New York
Kny-Scheerer Co., 17 Park place, New York
Queen & Co., 1010 Chestnut st., Philadelphia, Pa.
Richards & Co., New York
Spencer lens co., Buffalo, N. Y.
Ward's natural science establishment, 18–28 College av., Rochester, N. Y.
Williams, Brown & Earle, 918 Chestnut st., Philadelphia, Pa.

ZOOLOGIC SPECIMENS

Biological laboratory, Cold Spring Harbor, Long Island, N. Y.
Brimley, H. H. & C. S., Raleigh, N. C.
Ficklin, W. H., 2640 E. 8th st., Kansas City, Mo.
Marine biological laboratory, Dep't of laboratory supply, Woods Holl, Mass.
Wamsley, F. N., Bridgeton, N. J.
Ward's natural science establishment, 18–28 College av., Rochester, N. Y.

MICROSCOPIC PREPARATIONS

Drury, E. M., 119 St Botolph st., Boston, Mass.
Lutz, Annie M., Ann Arbor, Mich.

AQUARIUMS AND AQUARIUM SUPPLIES

Eggeling, O., 72 E. 125th st., New York

CHARLES WRIGHT DODGE
CHARLES W. HARGITT
FRANKLIN W. BARROWS } *Subcommittee on zoology*
JAMES E. PEABODY
THOMAS B. STOWELL

*To the committee of nine:*

While cordially agreeing with many of the recommendations of the majority of the committee on the secondary school course in zoology, I must dissent in the following particulars:

1 I believe zoology should be taught in the first year of the high school, and that it should form part of a course (five periods a week) to include the study of botany, zoology and human physiology.

In the report of the National educational association on college entrance requirements, it is recommended that the biologic studies precede physics and chemistry; and, since this national association is the one great unifying force in education in our country, it seems wise for our state association, if possible, to adopt this recommendation, and outline courses accordingly. Again, as long as the present law remains on the statute books in this state, human physiology must be taught in the first year of the high school. There may, therefore, be an advantageous concentration of the pupil's thought on biologic subjects, if botany and zoology are taught in the same year. Then, too, when the instruction in physiology is given from the standpoint of general biology, it will be possible to dignify the physiology and to redeem it from its present curse of close association with "liquor teaching."

Briefly stated, some of the arguments for assigning the biologic studies to the first year of the high school course are these: First, boys and girls then bring to the subject a keen interest in observing living things, an interest, if not cultivated, that is found to be almost wanting at a later time. Secondly, biology can be made more intelligible at that time than can the theories of geology, physics, and chemistry. And finally, by placing this subject on the first year, when the high school classes are the largest, there will be a much wider diffusion of practical biologic knowledge, which ought to contribute in no small degree to the making of a more healthy individual and a more healthful community.

2 In the biologic studies of the high school, emphasis, in my opinion, should be laid on function rather than on structure. There should be a relatively small amount of dissection by the pupil, and complicated scientific terms should be avoided whenever clearness of expression can be attained without their use.

Many of the details of comparative morphology, suggested in the preceding report, belong to college courses, when the student has developed the necessary reasoning powers to see the genetic relations that exist between animal forms. Again, since the high school classes of the first year are usually large, one teacher can not direct any considerable amount of minute dissection and get good results. So far as scientific terms are concerned, are we not often deluded in the belief that a correct use of these terms necessarily means that the pupil has gained a definite idea?

3 An elective course in zoology, similar to the one outlined by the majority of this committee, may well be given, when possible, in the last year of the high school.

JAMES E. PEABODY

## SUMMARY

In conclusion your committee present the following summary of their most important conclusions.

We offer the following recommendations in regard to

### 1 Nature study in the elementary schools

*a* We believe that nature study is indispensable in the education of children, and recommend that a continuous and progressive course, of the kind described in the report of the subcommittee on nature study, be made an integral part of all school study in the grades below the high school.

*b* That the aim of the course should be twofold: 1) To train the mind and character of the child; 2) To give definite knowledge which will be attractive and useful in itself, and at the same time helpful in the other work of the school.

*c* That the first part of the twofold aim requires the work to be so planned and conducted that it will involve a variety of exercises adapted to develop the powers of personal observation, reason, and expression, to lead the children to a better appreciation of the beauty of natural objects, and cultivate their natural sympathies with the world of life.

The second part of the aim requires that the exercises shall cover a wide range of topics which involve facts that will be most helpful in the other work of the school, such as the study of geography and of the introductions to the branches of science in the high school, and which, besides all this, will make nature study a proper basis for a part of the work in drawing, reading and composition.

*d* That the outline of topics prepared by the subcommittee on nature study and published in the proceedings of this association for 1898, if used in the light of the discussions which accompany it, is a suggestive and sufficient summary of the best subjects, and involves the most fruitful exercises for the purposes of nature study in the grades.

*e* That, for the better preparation of teachers for nature study work in the schools, we recognize the value of teachers classes for observational study; of summer schools, state and private; of the publication of syllabuses with practical suggestions for exercises in nature study, and we advise that the organization of these agencies be encouraged by science teachers and school authorities.

We offer the following recommendations in regard to

### 2 Science courses in secondary schools

*a* That the study of science be made an integral part of school work throughout the high school period, with educational aims as serious, and by methods as disciplinary, as those in the study of mathematics and Latin.

*b* That the sciences for school purposes be regarded as branches of a single whole — science, as algebra and geometry are branches of mathematics, and that they be treated in such way and placed in the program in such order, as to constitute a graded course. That in which the subject-matter and methods can be most easily adapted to the younger minds should take the earliest place.

*c* That advanced courses in those branches which must be treated most simply and less exhaustively in order to meet the educational demands of the first and second years, be taken, preferably as electives, in the fourth year.

*d* That the program of studies include a one year course in at least one branch of earth science, and one of biologic science and one of physical science.

(We regard the serious study of the elements of these three distinct divisions of science as a better secondary education in both its disciplinary and informational aspects, than a prolonged course in any one of them at the sacrifice of another.)

*e* That in science teaching not the textbook, the lecture, nor the laboratory method alone be adopted, but that oral instruction, textbook and library study, and laboratory or field work go hand in hand throughout the courses.

*f* That all the tests for scholarship and promotion shall be as severe in science as they are in English, Latin or mathematics.

*g* That the outlines of subject-matter prepared by the subcommittees on the several branches, if used in the light of the discussions of aims, methods and time allotment, may be trusted to secure the best educational values of the several branches in the high school courses.

*h* That physical geography, embracing as it does in an elementary way the first principles of several sciences, should be agreed on as the first year high school branch of science. It is most easily based on the nature study and geography of the grades below, and it is the best introduction to the branches of science in the years following.

### 3 Recognition of science in requirements for entrance to college

We recommend that any branch of earth science, or of biologic science, or of physical science, which has been pursued consecutively one full year of five hours a week, by the combined classroom, textbook and laboratory method, and which has stood the approved test (2, *f*) for quality, be accepted by the colleges for admission to their freshman classes.

| | |
|---|---|
| LeRoy C. Cooley<br>Albert L. Arey<br>William Hallock<br>George F. Atkinson<br>Charles B. Scott<br>Anna B. Comstock<br>Ralph S. Tarr<br>Richard E. Dodge<br>John D. Wilson | *Committee of nine* |

## REPORT OF COMMITTEE ON ALCOHOL AND NARCOTICS

**Prof. Bishop** — I have to report that the committee on alcohol and narcotics has organized and is at work. It has not however been able to complete the task assigned within the year, and it respectfully asks for more time. We believe at least another year will be necessary to cover the ground as carefully as the importance of the subject demands.

*Voted,* That the committee be continued.

## MISCELLANEOUS

**Prof. H. A. Surface** — I have a matter that I should like to bring before this association. It is the subject of a biologic station for the state of New York. This has been approved by the New York fish, game and forest league, and it ought to be of great interest to all teachers. The station in Illinois is fitting up buildings and houses. Such a station in New York ought to have educational value, as it would be able to supply schools with collections of specimens and material for scientific purposes.

It was moved that the association advocate the establishment of a state biologic station.

**Prof. S. H. Gage** — While I believe that the establishment of a biologic station would be of great advantage to the state, I think it would be very unwise for this association to take any action whatsoever. We should get ourselves entangled in politics. This matter must go before the legislature, as at present there is no such institution in the state. If there were such a laboratory and this association were to express to that laboratory a desire to have some of the material, for use in science instruction, there could be no objection. But, if we pass this resolution, it will be understood as an effort to get the station established. Now every person knows that any state station that is established has behind it an abominable lot of politics, and this association in its present stage of development can not afford to go into politics. So I hope we shall keep out of this. I am not saying a word against the establishment of this station; it would be an excellent thing to have such a station, but its procuring does not come within the sphere of this association. If we get a proper coordination of science work in the schools, we shall have enough to do. If we want to have a little station in our own school, very good, but let us not lend ourselves to getting up some big scheme altogether too ambitious for our present stage of development. If we stick to one thing, we shall accomplish something, but, if we go into politics, we shall meet with disaster.

**Prof. H. A. Surface**—I would state that this was advocated by the state fish culturists primarily. I know that the station in Illinois is not a political power. It does an immense amount of good in sending out collections of fishes, and is serving educational interests to such an extent that I feel justified for the sake of its educational value in introducing this matter here. In Illinois the station is not a part of the political machinery, and I do not see why it should be in New York.

It was voted to lay the matter on the table.

## MEMBERS 1900

When the name of an institution includes the name of its town or city, the latter is not given. Where no state abbreviation appears, New York is to be understood.

**Allen**, Charles M., Pratt institute, Brooklyn
Allen, John G., Rochester high school
Anderson, W. W., Dobbs Ferry
Andrews, Kate R., 24 Kelly Hall, University of Chicago, Ill.
Arey, Albert L., Rochester high school
Armstrong, Charles H., 109 W. 54th st., New York
Atkinson, George F., Cornell university, Ithaca

**Babcock**, Edward S., Alfred university
Bardwell, D. L., Binghamton
Barrows, Franklin W., 45 Park st., Buffalo
Beach, Channing E., 49 Day's park, Buffalo
Beach, Grace B., 322 St Nicholas av., New York
Beadel, Charles W., high school, Shamokin, Pa.
Bean, Charles M., Pulaski high school
Belknap, Emmet, Lockport
Bennett, R. Grant, Locust Valley

Benoliel, Sol D., 206 Washington park, Brooklyn
Bevier, Marie L., 106 W. 61st st., New York
Bickmore, Mary E., 30 W. 128th st., New York
Bigelow, Maurice A., Teachers college, New York
Bishop, Irving P., Buffalo normal school
Blackall, Gertrude C., Wilder building, Rochester
Blossom, Margaret, 440 Henry st., Brooklyn
Bogert, Marston T., Columbia university, New York
Bond, W. E., Potsdam normal school
Boniface, Sister M., Nazareth academy, Rochester
Booth, W. M., Cortland normal school
Bowers, Emma, 100 Hector st., Ithaca
Brace, Edith M., 131 Park av., Rochester
Bradley, Theodore J., Albany academy
Brigham, A. P., Colgate university, Hamilton
Bristol, Charles L., New York university
Britcher, Horace, 707 S. West st., Syracuse
Brownell, W. A., Syracuse high school
Brownlee, R. B., Brockport
Burgin, Bryan O., Lowville academy
Burlingham, Gertrude C., 93 Oak st., Binghamton

Caldwell, G. C., Cornell university, Ithaca
Call, Richard Ellsworth, Erasmus Hall high school, Brooklyn
Carey, E. L., St Johns college, Brooklyn
Carney, Frank, Keuka college
Carpenter, Idalette, Maplewood, N. J.
Carss, Elizabeth, Teachers college, New York
Cate, Eleazor, 16 Ashburton place, Boston, Mass.
Cattell, J. McKeen, Garrison on Hudson
Chambers, V. J., Geneva high school
Chesebrough, Thomas U., Littlefalls high school
Chollar, Sarah V., Potsdam normal school
Clapp, B. G., Fulton high school
Clark, John Anson, Ithaca high school
Clark, O. D., Brooklyn boys high school
Clark, Tracy E., 102 Macon st., Brooklyn
Clarke, John M., state paleontologist, Albany
Clement, Arthur G., Regents office, Albany
Cobb, Charles N., Regents office, Albany
Comstock, J. H., Cornell university, Ithaca

Cooley, LeRoy C., Vassar college, Poughkeepsie
Cornish, R. H., New York girls high school, 36 E. 12th st.
Curry, C. M., Cortland normal school
Curry, Mrs Sarah E., 70 N. Main st., Cortland
Curtis, Arthur M., Oneonta normal school

**Dann**, Mary E., 413 Clinton st., Brooklyn
Davenport, Charles B., University of Chicago, Ill.
Dean, Philip R., 60 W. 13th st., New York
Denham, Henry H., 142 N. Pearl st., Buffalo
DeShow, Charles H., 646 Elm st., Buffalo
Dodge, Charles Wright, University of Rochester
Dodge, Richard E., Teachers college, New York
Doll, Carrie L., 587 Ellicott st., Buffalo
Doremus, C. A., 59 W. 57th st., New York

**Elliott**, Arthur H., New Rochelle
Emerson, Josephine, Pratt institute, Brooklyn
Evans, Susan, 205 Court st., Rome

**Fish**, Pierre A., New York state veterinary college, Ithaca
Fleming, Mary A., 432 Pearl st., Buffalo
Fox, Ada H., Masten Park high school, Buffalo
Freedman, William H., 157 W. 119th st., New York
Freley, J. W., Wells college, Aurora
Furman, Bertha M., 69 W. 71st st., New York

**Gage**, Simon Henry, Cornell university, Ithaca
Gaines, E. V., Adelphi college, Brooklyn
Gardner, George S., Marion collegiate institute
Gibson, J. J., Montclair, N. J.
Gillmore, Gertrude, 49 Garden place, Brooklyn
Glavin, John F., St John's academy, Rensselaer
Goodrich, A. L., Utica free academy
Gorton, J. Irving, 22 Dale av., Sing Sing
Graham, W., Syracuse university
Greene, W. J., Lewiston
Greenwood, John W., Buffalo normal school
Griffis, Henry L., New Paltz normal school

**Haanel**, Eugene, Syracuse university
Hale, Albert C., 551 Putnam av., Brooklyn

Hallock, William, Columbia university, New York
Hancock, W. J., Erasmus Hall high school, Brooklyn
Hanna, Jennie P., 23 Prospect st., Rochester
Hargitt, Charles W., Syracuse university
Harper, Charles A., Columbia university, New York
Harris, C. Everett, 857 E. Main st., Rochester
Hastings, George T., 112 Stewart av., Ithaca
Hering, D. W., New York university
Hixon, Kate Burnett, 24 E. 128th st., New York
Hodges, G. C., 129 John st., Utica
Hopping, Roy, 129 4th av., New York
Hoxie, Jane L., 109 W. 54th st., New York
Hubbard, Dwight L., 117 W. 93d st., New York
Hudson, George H., Plattsburg normal school
Humphrey, O. D., Jamaica, L. I., state normal school
Hunt, Arthur E., Manual training high school, Brooklyn
Hurd, Frances, Oneonta normal school

**Jameson,** J. M., Pratt institute, Brooklyn
Jaquish, Benjamin M., 204 W. 106th st., New York
Jewett, Franklin N., Fredonia normal school

**Kauffman,** W. L., Yonkers high school
Kelly, Mrs H. A., 669 Madison av., New York
Kelly, Henry A., 109 W. 54th st., New York
Kemp, James Furman, Columbia university, New York
Kenyon, O. C., 110 Lancaster av., Syracuse
Kingsbury, George H., High school, Elmhurst
Kingsley, J. Stanton, Newark Valley
Kittredge, R. J., 520 Liberty st., Schenectady
Knapp, Allen H., Canton high school

**Langworthy,** William F., Colgate academy, Hamilton
Laurence, Clara Louise, Waterville
Lennon, Alice L., Brockport normal school
Lennon, W. H., Brockport normal school
Lewis, Fred Z., Brooklyn boys high school
Lewis, Mrs Lucy S., 30 Clifton place, Brooklyn
Linville, Henry R., 60 W. 13th st., New York
Lloyd, Francis E., Teachers college, New York
Loeb, Morris, New York university
Lovell, Thomas B., Niagara Falls high school

Lyon, Catherine E., 113 Greene place, Brooklyn
Lyon, Howard, Oneonta normal school

**MacClaughry,** Mollie, Saratoga Springs
McGreevy, Thomas, 200 Albany st., Buffalo
McKay, John S., 460 Green av., Brooklyn
McMurry, Frank M., Teachers college, New York
Mann, Warren, Potsdam normal school
Mar, Frederick W., Brooklyn boys high school
Marcella, Sister M., Nazareth academy, Rochester
Matteson, Florence M., Oneonta normal school
Maury, Mytton, 109 Cascadilla st., Ithaca
Mead, F. L., Madison school, Syracuse
Mercer, W. F., Chamberlain institute, Randolph
Merrell, William D., University of Rochester
Merrill, F. J. H., New York state museum, Albany
Milliman, Lennette G., Rochester high school
Moler, G. S., 106 University av., Ithaca
Moore, Katherine Rowe, Dresden
Morrey, William T., 58 W. 104th st., New York
Morrill, A. D., Hamilton college, Clinton
Morse, H. L. F., Troy high school
Murphy, Charles T., 353 Adelphi st. Brooklyn

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312309

University of the State of New York

# High School Department

Bulletin 13 May 1901

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## NEW YORK STATE SCIENCE TEACHERS ASSOCIATION

PROCEEDINGS OF THE

FIFTH ~~FOURTH~~ ANNUAL CONFERENCE

Held at Rochester university, Rochester, 28–29 December 1900

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1901

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## University of the State of New York

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University of the State of New York

# High School Department

Bulletin 13 May 1901

## New York State Science Teachers Association

## PROCEEDINGS OF THE FIFTH ANNUAL CONFERENCE

Held at University of Rochester, Rochester, 28-29 December 1900

### SUMMARY OF SESSIONS

Friday, 28 December, 9.30 a. m.

Meeting of executive council

Registration

Opening session; called to order by Prof. LEROY C. COOLEY, *chairman*

Address of welcome
  Pres. RUSH RHEES, University of Rochester

Response
  Prof. LEROY C. COOLEY, Vassar college, retiring president of the association

Introduction by Prof. LEROY C. COOLEY of Pres.-elect CHARLES W. DODGE, University of Rochester

Remarks
  Prof. CHARLES W. DODGE

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1905

The method of science and the public school
Prof. S. A. Forbes, University of Illinois
Discussion
Prof. W. J. Beal, Michigan agricultural college
Prof. Henry S. Carhart, University of Michigan
Prof. Frank M. McMurry, Teachers college'
Prof. S. A. Forbes, University of Illinois

**Friday, 2.30 p. m.**

Section meetings

Section A—Physics and chemistry. Prof. Henry E. Lawrence, University of Rochester, *chairman*
Place of physics in a liberal education
Prof. Henry S. Carhart, University of Michigan
Devices useful for demonstration purposes
Prof. Edward L. Nichols, Cornell university

Section B—Biology. Prof. James H. Stoller, Union university, *chairman*
Teaching physiology in secondary schools
Prof. Frederic S. Lee, Columbia university
Discussion
Dr Charles Forbes
Inspector A. G. Clement, Regents office, Albany
How shall a young person study botany?
Prof. W. J. Beal, Michigan agricultural college

Section C—Earth science. Prof. Ralph S. Tarr, Cornell university, *chairman*
Practical exercises in physical geography
Prof. W. M. Davis, Harvard university
Discussion
Prin. G. H. Walden, Rochester school no. 10
Prof. I. P. Bishop, Buffalo normal school
Prof. W. T. Morrey, Peter Cooper high school
Prin. Frank Carney, Keuka institute
R. H. Whitbeck, Cornell university
Prof. W. M. Davis, Harvard university

Section D—Nature study. Prin. CHANNING E. BEACH, Buffalo school no. 23, *chairman*
  Significance and limitations of nature work
    Prof. STANLEY COULTER, Purdue university
  Synthetic nature study
    Sup't HENRY A. KELLY, Ethical culture schools, New York
  Discussion
    Prof. J. H. COMSTOCK, Cornell university
    Prof. STANLEY COULTER, Purdue university
    Inspector C. N. COBB, Regents office, Albany
    Prof. HENRY A. KELLY, Ethical culture schools, New York

General session—Symposium

College entrance demands on the scientific student
    Prof. C. W. DODGE, University of Rochester
    Prof. E. H. NICHOLS, Cornell university
    Prof. W. J. BEAL, Michigan agricultural college
    Prof. F. S. LEE, Columbia university
    Prof. STANLEY COULTER, Purdue university
    Prof. W. M. DAVIS, Harvard university
    Prof. I. P. BISHOP, Buffalo normal school

**Friday, 8 p. m.**

The scientific basis of modern industry
    Dean J. B. JOHNSON, University of Wisconsin
    Prof. R. H. THURSTON, Cornell university

**Saturday, 29 December, 9.30 a. m.**

Section A—Physics and chemistry. Prof. HENRY E. LAWRENCE, University of Rochester, *chairman*
  Relation of high school to college physics
    Prof. JOHN S. SHEARER, Cornell university
    Prof. OTIS HALL ROBINSON, University of Rochester
  Manual training of chemistry
    Prof. WILLIAM E. BENNETT, Rochester high school
  Relative value of the qualitative and the quantitative in laboratory work
    Prof. W. C. PECKHAM, Adelphi college

Prof. W. J. Beal, Michigan agricultural college
Prof. C. G. Rogers, Syracuse university
Prof. H. R. Linville, DeWitt Clinton high school, Ne York
Inspector A. G. Clement, Regents office, Albany
Zoology in secondary education
Prof. Jacob E. Reighard, University of Michigan
Discussion
Dr F. W. Barrows, Buffalo central high school
Inspector A. G. Clement, Regents office, Albany
Prof. Henry R. Linville, DeWitt Clinton high scho New York

Section C—Earth science. Prof. Richard E. Dodge, Teache college, *chairman*
Theses on geography
Prof. F. M. McMurry, Teachers college
Discussion
Inspector C. F. Wheelock, Regents office, Albany
Sup't Jay Crissey, Penn Yan
Prin. Frank Carney, Keuka institute
Prof. Grant Karr, Oswego normal school
R. H. Whitbeck, Cornell university
Personal equipment of teachers of geology and geography
Prof. Albert P. Brigham, Colgate university
Purposes of geography
Prof. Amos W. Farnham, Oswego normal school

Nature study and the grade teacher
    Mrs A. B. **Comstock**, Cornell university
Nature study in practice
    Prin. E. J. **Cobb**, Buffalo school no. 60
  Discussion
    Mrs A. B. **Comstock**, Cornell university
    Prof. **John W. Spencer**, Cornell university

General session

Moral value of science studies
    Prin. **Frank Carney**, Keuka institute
Work of the junior naturalists clubs
    Prof. **John W. Spencer**, Cornell university
*Adjourned*

## SUMMARY OF ACTION

### Committee reports

**Alcohol and narcotics.** The committee on alcohol and narcotics reported progress and asked for an extension of time.

*Granted*

**Resolutions.** The following resolutions were reported, and adopted.

*Resolved*, That we extend our hearty thanks to our visitors from other states who have responded so generously and acceptably to our president's invitation, by presenting papers and addresses, and by contributing in many ways to the success of this meeting.

*Resolved*, That we extend to the faculty and trustees of the University of Rochester our hearty thanks for their hospitality in providing us a place of meeting and in extending to us all those courtesies and attentions which have made us actually at home with them.

**Nominations.** The committee reported the following.

*President*, Franklin W. Barrows, Buffalo central high school
*Vice-president*, Frank M. McMurry, Columbia university
*Secretary and treasurer*, A. R. Warner, Auburn high school

*Executive council*, James H. Stoller, Union university; Thomas B. Lovell, Niagara Falls high school; William C. Peckham, Adelphi college, Brooklyn

On motion, the secretary cast the ballot of the association, and the nominees were declared elected.

### Treasurer's report

For the year ending 29 Dec. 1900

*Receipts*

| | | |
|---|---|---|
| Balance in treasury | $138 29 | |
| Annual dues | 139 .. | |
| Interest | 1 89 | $279 18 |

*Disbursements*

| | | |
|---|---|---|
| Collections on checks | $ 80 | |
| Printing | 31 95 | |
| Postage and expressage | 26 25 | |
| Clerical work | 12 60 | |
| Telegram | 47 | |
| Trunk line association | 11 .. | 83 07 |
| Balance on hand, 29 Dec. 1900 | | $196 11 |

*Adopted*

### Report of auditing committee

The auditing committee has examined the treasurer's report submitted today by Mr Kenyon, and find it correct in every particular.

Franklin W. Barrows *chairman*
James H. Stoller

### Motions

**Exercises in earth science.** The chairman of section C, earth science, presented the following motion, on behalf of the section.

*Moved*, That the earth science section of the New York state science teachers association request the president to appoint a committee of seven to consider the preparation of a series of exercises and suggest a course of study for public and high school laboratory and field work, and report at our next annual meeting.

The motion was carried, the committee to be announced later.

**Apparatus.** The following resolution, offered by the chairman of section A, physics and chemistry, was adopted.

*Resolved*, That a chairman be appointed on a committee of exhibit to see to it that an exhibit of apparatus is presented at the meeting of the association next year.

**Meeting of 1901.** The president announced that the next meeting of the association will be held at Syracuse, the date to be announced later.

## ADDRESSES, PAPERS AND DISCUSSIONS

### Friday morning, 28 December

**Pres. L. C. Cooley**—It is my privilege to call to order the New York state science teachers association at this first session of its fifth annual conference, and at the same time to announce the pleasant fact that we may at once listen to the president of this university that has so kindly opened its doors for our meetings. I have the honor to present Pres. Rush Rhees of the University of Rochester.

**Pres. Rush Rhees**—It is a very great pleasure, Mr President and ladies and gentlemen, to offer to you a welcome in behalf of the college which I represent and in whose halls you are meeting, and also in behalf of the city in which we dwell. I feel perfectly at liberty to offer you the freedom of the college and ask you to make use of it in the fullest sense. I also feel free to offer to you the freedom of the city, partly because in my short stay here I have experienced the hospitality that the city gives, and partly because I know the cordiality with which our people welcome your coming. We have been empowered to offer you the privilege of inspecting some of the most interesting industrial works in the country, which will be opened to you as already announced. In these ways, therefore, the city offers its full freedom and its hospitality.

I can not resist the temptation, standing before you in this way, to express the interest I feel as a teacher of literature in your presence and your work. It is far from my purpose to undertake in any way a discussion of the results of your deliberations; you know them far better than I. I would simply quote a story I have heard, of a little boy who was given the task of writing a composition on the modern method of telling what he knew and what interested him. The subject assigned was man. I suppose the modern teacher of literature would not give so unrestricted a subject; but the boy used his brains and his eyes as well as his own method of expression, and the result was: "Man is a long thing, not very broad, split through the middle, and walks on the split end." This composition showed the result of individual observation; and, as a teacher of literature, I feel interested in your work because you are teaching boys and girls to see things and tell what they have seen. Probably there is nothing more promising from an educational point of view than this discipline in the use of the senses and a simple candid expression of the result of that use. Your presence here will be a stimulus to our work. It will do us great good. We feel honored in your presence, and simply desire that you will show us the courtesy of making yourselves at home as fully as possible. You are very welcome.

**Prof. LeRoy C. Cooley**—In behalf of the association, Pres. Rhees, I desire to thank you heartily for your cordial welcome to the university and to the city of Rochester. The kindness of your greeting has intensified our pleasure in coming together. We are glad that we are here; and I am sure that our appreciation of the hospitality tendered us is commensurate with the cordiality of your generous welcome.

You have referred to our association and our work in terms that lead me to believe that I need not now enter on any details in regard to its purpose or its methods. You know already that we are a people devoted to the promotion of science as an educational agent. You know that we have come from the classrooms and the laboratories of the elementary and secondary schools, of the normal schools, of the colleges and of the universities to talk over past experiences, to compare notes in regard to the progress of the work which we have at heart, to enjoy the pleasures of mutual acquaintance and good-fellowship and to discuss methods by which to enable this great department of human knowledge to bear an honorable share in the preparation of the young for the manifold duties of citizenship.

The kindness of our hosts is one of the inducements to us to make this meeting, if possible, the very best in the history of the association. I know that this will be a difficult task, but we have on our excellent program papers on a great variety of educational subjects. Some deal with those practical details that are supremely important to all who are interested in the actual work of using science for educational purposes. Others deal with the philosophy which shapes our purposes and the principles which underlie our practices. Moreover, those who have consented to prepare these papers and discussions are recognized as most successful specialists, whose eminent scholarship and long experience in school and college work entitle them to speak on the subjects involved. We therefore hope that, during this meeting of the association, our hosts from whom we are to receive so much, will be able to receive something of interest and profit from us in return.

I can not let pass this opportunity to thank the association for the great honor it placed on me in calling me to be its president, and to express appreciation of the courtesies which have been extended to me while I have attempted to discharge the duties of that high office. The last of these duties I now discharge. With keenest pleasure I introduce to the association its new president, Prof. Charles Wright Dodge of the University of Rochester.

**Prof. Charles W. Dodge**—I wish to thank the association for the great honor it has conferred on me in electing me president for this year. It is not only an honor, but a great privilege to be the president of this association, representing as it does the entire school system of New York state from the kindergarten to the university, and including as it does, I think, the largest membership of such organizations in this country. Along with the honor and the privilege, there also come to the president many obligations, the most important of which is the preparation of a program for the meeting over which he presides. It is a great compliment to the association and an indication of the position it has attained during the few years of its existence, that it has been able to secure for this meeting so large an attendance of men not only eminent as investigators in science but specially so as teachers of science. There was a general request in the suggestions that I received in regard to a program, that we should have addresses from those who had not spoken to us before. We are a rather voluble set of people, I thought on looking over the reports of the past meetings, for there are not many members who have not spoken; and it became a necessary as well as very pleasant duty to invite speakers from outside the state. We want to know what is done in other institutions; so we have on the program for this meeting a number of men who are not connected with our state system of education at all. I hope and expect that we shall get from them some most suggestive ideas; and, I think, from none shall we receive more than from the speaker who is to address us this morning on the subject, the scientific method and the public school. I have very great pleasure, indeed, in introducing Prof. S. A. Forbes, professor of zoology and director of the biologic laboratory of the University of Illinois.

## THE METHOD OF SCIENCE AND THE PUBLIC SCHOOL

### BY PROF. S. A. FORBES, UNIVERSITY OF ILLINOIS

"God forbid," says Bacon, "that we should give out a dream of our imagination for a pattern of the world"; a judicious and earnest prayer, an affirmative answer to which has often been denied to us, for patterns of the world which are such stuff as dreams are made of are still not infrequently turned out from the loom of man's imagination. Bacon, as all know, did not content himself with empty petitions, but made a famous effort to develop and establish a method of investigation of the truth of nature which should insure a real and not an imaginary product. His "inductive method" brought him immortal fame, but it has, nevertheless, in the form in which he left it, been of remarkably little use to the actual investigator. His idea, that general knowledge of the highest character could be acquired from immense accumulations of facts by mechanically repeating on them the process of inductive generalization till laws of the highest grade were reached, has proven unfruitful of scientific results, and, indeed, impracticable except in limited fields; but it has nevertheless contributed largely to the formation of that finished method of modern science a discussion of which I have been asked to open.

The term, method of science, is often somewhat loosely used, and is not commonly applied, I think, to the abstract sciences of logic and mathematics. The method of physical science is what is ordinarily meant by it, and we may provisionally use it in this sense; for, as I shall presently try to show, the full physical science method is the complete method of science, other scientific methods being fragments or abbreviations of it only. But the physical sciences—chemistry, physics, astronomy, geology, biology, etc.—do not agree in their methods in all respects. The method of chemistry is so different in some respects from that of physics that one trained in chemical methods needs much more than a mere knowledge of the facts of physics to become a physicist, and no training in physics with chemical knowledge superadded will make an expert chemist. A man may be never so much a chemist or physicist or both, but he can not then become a competent biologist by merely learning any number of facts about biology; he must still have his training in the special biologic method. But, notwithstanding minor diversities in the methods of the separate sciences, there are certain main features common to them all which may be abstracted, generalized and stated in comprehensive form; and these constitute what we may call the method of science in our sense of the term.

But what shall we mean by method in this discussion? Not the mere use of tools of any sort, however complicated and invaluable; not the manipulation of apparatus, or any form of mechanical operation on anything. Tools, apparatus, and laboratory manipulations and experiments are helps to observation, indispensable often in the accumulation of facts, but they do not themselves accumulate facts, and they do not in the least help to organize the facts accumulated, or to reason on them when organized. The method of even physical science is indeed a mental method, and the study of this method is a study of the action of the scientific mind while engaged in the pursuit of scientific truth. The subject is thus not physical but psychologic, and the question which we wish to find an answer for is, I think, substantially this: What are the general features of mental method common to all sound and successful investigations in the physical, or concrete, sciences? This is a question of the greatest importance to us all, for this method of science must always be our final means of defense against the ravages of unbridled fantasy in the field of general truth; a defense never more needed than now by that mass of the ignorant, the partly educated, and the poorly educated, who still make up the great bulk of humankind. I shall try to answer this question as well as I can in a little time by giving an outline description, brief and necessarily somewhat crude, of the various steps or stages in the method of the scientific man engaged in the serious study of a new, difficult, and complicated problem.

The first step in any such study is the investigation of the investigator by himself. He is to look on himself as his own apparatus of research, certainly defective in various ways and never capable of being fully perfected for its purposes, to be studied therefore with a view to correcting its action where possible, and of guarding against its deficiencies and allowing for its irregularities where this can not be done. What is the temperamental bias of the investigator? Is he unduly optimistic, or is he too easily discouraged? Is he already committed to general views which are likely to create a prejudice in the case which, as the lawyers say, it will take evidence to overcome? Is he too quick to generalize and thus likely to proceed under the influence of premature opinions; or is he overcautious, hesitating to draw conclusions which are warranted by the evidence, and thus likely to stand in his own way and block his own advance? Has he a well fixed habit of sure and steady work, such that he may safely close each stage of his investigation as he finishes it; or must he go over each step of it again and again, suspecting his own thoroughness and exactness, till everything has been tested in every way he can contrive? These are examples merely of the searching questions which the conscientious investigator puts to himself till he is sure that he understands himself thoroughly as an apparatus of investigation. And he can not finish this task of scrutiny, discipline and self-correction once for all, settling down thereafter satisfied. He is fortunately organized indeed if he does not have to keep a close eye on himself for a very long time, as one liable to relapse into the inaccuracies of the ordinary untrained man, or to fall incautiously under the influence of original defects not yet wholly overcome.

His systematic research he will begin by an accumulation of the facts necessary to a study of his problem—if these have not been already accumulated by himself or by some one else—and he will be specially watchful at this point that no superfluous assumptions slip unnoticed into the company of his primary data; no assumptions, that is, which are not necessary to the beginning and the continuance of his work. There is no error in pseudo-science more common than this perfectly fatal one of a conscious or unconscious assumption in the beginning, of things not known and not in the nature of the fundamental presuppositions of scientific thought. Assumptions we all of us must make every time we rationally think and every time we deliberately act, but it is a fundamental principle of scientific law that the investigator shall make no assumptions not necessary to the constitution of his science and to the use of its legitimate method. If a physicist, he will not call in question the real existence of energy or motion or the validity of the mathematical laws which he makes use of in his reasoning; if a biologist, he will assume the soundness of the generally received conclusions of physics and of chemistry; and, whatever his specialty may be, if a scientific man, he will not as such question the real existence of an objective world, the truth of the law of causation, or the principle of the uniformity of nature. These are assumptions so necessary to his purpose that, if he could work without them at all, it would only be at an enormous expense of labor and convenience. He may be perhaps a thoroughgoing idealist in metaphysics, but when he steps into his laboratory, he leaves all that behind him, for there he thinks in other terms, and his mind speaks a language which he could translate into the dialect of idealism only by using the dictionary on every word. And in the accumulation of his facts, he will see—as well as he can at this stage of his procedure—that each is well and thoroughly known; that all are pertinent to his end; and that they are sufficient in number, variety, range and bearing to furnish a strong and broad foundation for the superstructure he has planned. This is the period at which great waste of labor may easily occur through the gathering together of materials excessive in some places, deficient in others, and wholly useless, because inapplicable, in others still. The end in view, the question to be answered, must be carefully kept in mind as a guide to choice.

Then,as he goes on, or after this accumulation stage is passed, he classifies his more or less complex material, he assorts his facts in bundles of like kinds, putting a general label on each one, and goes on perhaps to make larger bundles of these bundles, and then larger bundles still of these, so labeling each package as he goes that he can thereafter use the general label as a substitute or symbol for the compound package itself. And this classifying and generalizing process is also guided by the end he has in view, and the generalizations reached by it will all be such as have a bearing on the subject of his inquiry. If he does not thus directly reach the general truth of which he is in search—and in a difficult subject he commonly will not—he will at least greatly limit the field of his inquiry. Among his several generalizations may be one or more which will seem to point the way to the true law or principle which he seeks. And then he begins to guess—within limits; he turns his imagination loose—under guard; he invents hypotheses—consistent with the facts; he employs the method of multiple hypotheses, perhaps; that is, he imagines all the various theories he can think of which are not contradicted by the facts as they then appear to him, and somewhere among the fish now tumbling into his net he expects to find the one with the golden coin in its mouth.

So far we have followed the accumulating, the combining, the inductive side of the method of science, but now, having reached our higher generalizations or our tentative hypotheses, one or more, how can we choose with certainty between them; how may we know which of them is true, or whether any one is true? We must proceed somewhat as the pupil does at school when he proves his division by multiplying divisor and quotient to get the dividend; that is, we must reverse the process, and, having reached certain general conclusions by induction from particulars, we must now reason deductively from these general conclusions to particulars again, and then must compare our reasoned-out particulars with those derived from observation or experiment. We do this not only once, but again and again, in as many ways as we can think of, and if all turns out as it should by our hypothesis, then we are sure that our problem is correctly solved. If we are dealing with several mutually inconsistent hypotheses instead of one, then we reason out the various consequences of each, compare all with the facts, previously known or subsequently ascertained, and exclude those hypotheses which are not sustained by this method of trial, this verification process as it is commonly called.

The accumulation of pertinent observations, the classification and generalization of them, the framing of hypotheses from the materials thus obtained, deduction from these hypotheses and comparison of the products of these deductions in every way possible with new facts till substantial certainty is reached, these are the general steps of the method of physical science. It is time to say, however, that in practice, and specially in some of the sciences, this whole round is rarely followed out in full. Short cuts across corners, abbreviations or even omissions of certain steps of the process are often possible to the expert, who may see, as by a flash of judgment, whither an investigation is tending, and so jump to the point at once; but even an expert may not dispense with a sure starting point and a rigid verification. If one omits or obscures these, we may know that he is not even a scientific man at all.

In physics or in chemistry a single observation or experiment is often enough to suggest to an acute and fertile mind a hypothetic explanation which brings the experimenter at once to the verification stage of his inquiry. In many departments of science vast masses of material have already been accumulated, classified, and generalized in advance, ready for the use of any one; and investigation in these departments may begin with imagined hypotheses, followed by verification through experiment and by added observation. In mathematics specially, induction was long ago practically completed, and the mathematician is occupied now only with deductive and verification processes. Physics and chemistry also have gone some distance on the same road, and general laws have been established in considerable number and of extensive scope, from which deductions may be made at once, and by reference to which new facts may be explained without the tedious preliminaries of extensive observation and repeated generalization. In the vast field of biology, on the other hand, full as it is of the most perplexing complications, few stable generalizations have as yet been reached, and there most students are still busy with the inductive side of the operation. They are working toward general propositions, while the mathematicians and physicists are working from them. Induction predominates, in short, in the more complicated, that is the less developed, sciences, and the deductive method in those which are far advanced.

The appreciation of these differences of method in the different related sciences is of great practical importance, since it is not an uncommon error to apply the method of one science in the field of another to which it is not appropriate. One trained mainly in chemistry, accustomed to infer with certainty the characters of a whole class from the results of an examination of his first example of it, knows little of the tedious repetitions of observation on multitudes of individuals, and the complicated processes of generalization necessary to establish class characters in zoology or botany; and the mathematician, accustomed to go at once to his general principles as an unalterable point of departure, can scarcely appreciate the requirements of an investigator who must start from individual instances, with general principles as the halfway house to his goal.

I must next make brief reference to two kinds of operation which, though they may not properly be described as parts or even varieties of the strict method of science, are, nevertheless, so helpful in scientific research, of such constant utility for inductive investigation, that the practical investigator would spare almost any other tools from his workshop as willingly. These are reasoning by analogy and the calculation of averages, the latter often used as a basis for the estimation of probabilities also. Analogic reasoning and the estimation of probabilities are indeed such clever tools and so convenient to the hand, they work so easily and so rapidly, that one is often strongly tempted to pick them up when only a heavier instrument and a slower operation are really adequate to the task in hand. On this account they commend themselves specially to the unscientific as a substitute for the scientific method. The principle of analogy, "like causes produce like effects," has a very plausible sound, and, if it were always and strictly true, it would save an immense amount of minute comparison and critical analysis of things which are clearly much alike, but not certainly like enough or like in the right way. What the untrained man will accept as a conclusion, and proceed to act on, the trained man will use as a promising hypothesis merely, not to be fully accepted till verified. But in the suggestion of hypotheses the method of analogy has a brilliant record in the annals of science in every age.

Scarcely less useful and scarcely less treacherous is the method of averages and the estimation of probabilities. From an imperfect examination of a part to assume a sufficient knowledge of the whole, is one of the forms of the abuse of a method which, properly used, enables the student to penetrate to definite conclusions through thickets of difficulty which would otherwise be wholly impassable to him.

I am not at all sure that my abstract description of the process of the scientific search for truth has been sufficiently clear to all of you to permit me to dispense with concrete illustration, and it may prevent misunderstandings and remove ambiguities if I illustrate it by some two or three examples. Let us take first a plain and simple problem, to the solution of which the full round of the scientific method may profitably be applied. I should like particularly to take an illustration from the work of one of the agricultural experiment stations, because these are excellent examples of organizations for strict scientific research, the thorough method of whose work is too little appreciated, and the educational and scientific value of whose results is too little known.

Let us suppose that an experiment station assistant is charged with an investigation intended to lead to a discovery of the best method of feeding stock for the purpose of growing them rapidly and fattening them early with the greatest economic profit. He might conceivably begin in any one of several ways, but he will most likely first avail himself of the various conclusions of other men, scientific and practical, who have had experience or made investigations in his field, adopting their announced results as his hypotheses merely, and proceeding at once to test them by deduction and experiment. That is, he will assume that the necessary accumulation and generalization of data have already been done by other men, and that he can omit these first steps of his research. Suppose, however, that he lacks confidence in previous work, and feels it necessary to begin at the very beginning for himself. Under these conditions he would probably first search out and bring together the largest possible number of instances of marked success in cattle feeding, with full particulars of the conditions and procedure in each. For comparison with these he would collect a large, if not an equal, number of unsuccessful instances. Each set of cases he would then compare among themselves, the first with a view to ascertaining what were the common features of the food and of the treatment generally in the practice of the successful feeder; the second to see also what common features could be distinguished as characteristic of unsuccessful practice, but specially to see whether those found characteristic of the successful group were wanting in the unsuccessful. In this manner he would analyze his data by what is known to inductive logicians as the joint method of agreement and difference. Remembering that a multitude of factors would affect results, besides the kinds of food made use of, that some of these factors would be favorable and others unfavorable in each group of cases, and that the effects of feeding would thus be more or less obscured, he would not stint himself in respect to instances, for the larger his accumulation the more completely these obscuring tendencies would counteract each other, leaving the different effects of different food to stand out clear and unmistakable. He would apply the method of averages, in short.

The general propositions thus arrived at as to the practice of successful feeders would at least contain materials for hypotheses concerning the most successful feeding practice possible, and these hypotheses our experimental agriculturist would next proceed to frame, and, with them in mind, he would arrange his scheme of experimentation to test them separately. And, knowing, as he will, that in the rearing of every animal, no matter how carefully chosen and skilfully handled, peculiarities of constitution, of condition, and of treatment are sure to occur, such that no safe inductions can be made from single instances, he will multiply identical experiments and eliminate his variations and errors by averaging his results. Remembering also the inevitable differences of environment and condition under which stock is reared in his state, he will so vary his feeding experiments as to imitate as closely as may be these interfering circumstances, and, finally, by a comparison of these results, after some years of careful work, he will reach conclusions as to the ideally best food and the best methods of feeding for various kinds of stock under the various conditions of actual practice on the ordinary farm.

In farther illustration of the scientific method as practised in the experiment station, I will describe not an imaginary but a real research, which is of special interest to us here from the fact that it was conducted partly at Cornell university and partly at the University of Illinois, and that its very notable results have been published in part by both institutions.

In 1896 Dr Cyril G. Hopkins, then experiment station chemist in Illinois, now professor of agronomy in the university of that state, set himself the task of ascertaining whether Indian corn might be improved for human use in respect to its chemical composition; whether breeds or varieties of corn might be developed which should contain more proteids than the present average, or more fat, or less starch, for example. In asking himself this question the investigator framed, in effect, an affirmative hypothesis. He assumed for the purposes of his investigation that such chemical varieties might be developed in corn, and then he undertook to test or verify this assumption by deducing its consequences and by comparing them with the facts. We have first to notice that this hypothesis was suggested to him by analogy. "That the chemical composition of corn can be changed," he says, "seems reasonably probable from the changes which have been produced in some other plants—notably in the sugar beet." And again, "the method of procedure which seemed most promising is based upon the common method of making improvement in animals, namely, selecting the best examples of the desired type and breeding successively and under the best conditions from that stock, retaining from each generation only the highest types obtained. This is practically the method by which the sugar content of certain varieties of beets has been increased from less than 5% to 12% or even 16%."

Now, to the formation of a variety by repeated selective breeding two things are indispensable as preliminaries: the organism under experiment must be variable, and its variations must be capable of transmission by inheritance. If from corn new chemical varieties can be formed, then corn must vary in chemical composition, and the chemical peculiarities of a given selected lot must tend to reappear in its produce. Deductions, these are, from the assumed hypothesis, to be compared with the facts as ascertained. Is the chemical composition of corn variable in definite ways? A long series of analyses furnished the grounds for a generalization in the affirmative. Different ears of corn do vary widely in the proportions of their main ingredients, and these chemical variations appear within the same variety, within the crop of the same year, within the product of the same small plot. Are these variations of chemical proportion reproduced at all in the next generation of the plant? Many series of plantings from variously selected seed, carried on now for four successive years, have furnished the materials for another affirmative generalization, to the effect that the chemical peculiarities of the seed do tend to appear to a notable degree in the produce of the planting. The original hypothesis is thus far verified, and the foundation is laid for the next step in the investigation, which is to ascertain whether *permanent* varieties can thus be formed which will perpetuate themselves indefinitely without an annual selection of seed by the use of special tests. To answer this question finally, to test this hypothesis thoroughly, will take additional years of expert and faithful labor.

Allow me a farther instance or two from a field in which I am personally more at home, that of the Illinois biologic station in operation under my direction. In August 1898 I detailed a young assistant, Wallace Craig, for a study of the local distribution and the movements of the fishes of our station field, with a view to making out the choices of environment, the preferences as to situation of the various species of fish under varying conditions and at different times of the year, together with any similar matters which might come to our net. Guided by analogy, I undertook to transfer and adapt to ichthyology the statistical method of research, the method of averages that is, which has brought an abundant harvest of new knowledge to the student of the forms and multitudes of minute aquatic life. Many fish traps and nets of uniform character were kept continuously set for eight months, from August to April, or were used at regular intervals in carefully chosen situations. The product of each net and trap was determined and counted for each species every few days, and later the data as to species of fish and the relative numbers of each were tabulated for each situation and each date. These collections and observations were the primary data of our investigation, so grouped and classified in the tables as to disclose the general conclusions of which we were in search. By a comparison of totals and averages for the various situations in our field it was learned, among other things, that the fishes of the locality are divisible into three main groups, inhabiting respectively the river, the lakes, and the creeks. These groups are distinguished not by differences with respect to the presence or absence of species but by differences in their relative abundance, and they are clearly recognizable even where there is a free open-water connections between their habitats. The river fishes are in general the oldest and the least specialized, and the most closely related to those of the Mississippi, into which indeed all of them still range, a few migrating from the gulf. The fishes from the bottom land lakes are, on the whole, more recent forms than those of the river, smaller, and more highly specialized. Those of the creeks are smaller still and most highly specialized of all. Farther, the Illinois river at the situation studied is frequently muddy on one side and clear on the other, owing to differences in the banks and the character of the entering streams. Where this difference exists, clear water and muddy water groups of fishes are distinguishable, but, when for any reason this physical difference is obliterated for a time, the distinction of these groups is obliterated also. The spring migration impulse connected with the search for breeding grounds likewise confuses all these groups for the time being in a general movement up the streams and into shallow water. Each of these generalizations, I need hardly say, invites to additional research, as to its general and uniform validity and as to the causes of the phenomena which it sets forth.

The preponderance of observation, classification, and generalization in biologic work over deduction and experiment is illustrated by the foregoing, but better still by the general operations of our biologic station during the past six years. Founded in 1894, specially for the experimental investigation of oecological subjects, this station has now published several hundred pages of contributions to knowledge and has some hundreds more just passing through the press, but has not yet reported or matured so much as one experiment. This is because in such a field one can not even see the outlines of the special problems to be worked on till its contents have been surveyed, classified, and analyzed, and this preliminary procedure is with us scarcely yet complete.

I think that I need not farther multiply instances of the application or the variations of the method of science, and I have accomplished my present purpose thus far, if I have given you an outline of its main features comprehensible to those not already familiar with the subject, and have opened the way for a discussion of the relations of the scientific method to the teaching of the sciences in our public schools.

At this point I specially feel the necessity of proceeding carefully, since my opportunities to learn by personal observation or by authentic report what is actually done in the science work of the schools are much inferior to those of many here present. On this account, I will limit my comments to certain methods of science teaching, wherever used, considered in relation to the method of science as above described. Take, for example, the laboratory method in biology, commonly so called. The student under instruction by this method sits at his table with a lifeless object before him of more or less complicated structure and a book beside him, which is essentially a manual of directions as to the mechanical routine of his work, a nomenclator of the parts of the object under his examination, and a more or less definite description of it, with broad intimations and pointed hints as to features not specifically described which it is desirable that he should see. He reads the book, he does the things he is told to do, he looks at the things he is told to see, he observes and records and draws, and he listens to the remarks of his instructor, and in it all he does not so much as lift one foot from the earth on which rests the lower end of the ladder which we call the scientific method. From our standpoint this is all prescribed and directed observation merely. If, in passing from object to object of the series laid out for him, he makes comparison of one with another, noting resemblances and differences between them, then he does lift his foot as if to place it on the lowest round, but he can hardly be said actually to place it there unless he goes at least so far as to frame a definition of a class by combining the results of these comparisons into a list of characters common to the group. Even the determination or identification method, if we may so call it, despised and rejected of teachers of biology for these many years, carries the student at least as far as this in the practice of the scientific method, and gives him at the same time a more exacting elementary drill; for one can not determine a plant or an insect species without close and careful observation or without answering positively for himself, yes or no, to a considerable series of questions, each compelling the comparison of his visible object with a conceptual image.

If we turn to what I suppose to be the more common methods of instruction in the chemical and physical laboratories of the public school, we find no very unlike condition of things so far as I now see. A chemical determination calls for a very different mechanical procedure from that of a botanical or an entomologic one, but the mental act is almost precisely the same. The student observes his mixture of substances and compares its behavior or the product of its reactions with certain descriptive matter in his book or in his memory, makes an identification based on that comparison, and with this elementary classification process his use of the method of science commonly seems to stop. In the physical laboratory his work is either illustrative of general principles taught him, or, at the best, he works out what is called a problem: given such and such an apparatus to prove by experiment such and such a law. His procedure is practically dictated, and his result is predetermined. If he reaches a different conclusion by his experiment from that prescribed to him in advance, which is it that he doubts, the experiment or the law? Unquestionably the former, and he works it over and over again, if necessary, till the answer to it "agrees with that in the book." This seems to be largely a drill in a mechanical operation rather than a practice in a mental method.

We must distinguish between a study of science and scientific study, between instruction in science and scientific instruction. If by scientific we mean "pursuant to the method of science," then the courses just described are unscientific, and instruction in them is instruction in science, it may be, but not scientific instruction. If we would teach science for its method, we must so teach it as to bring that method into play; and this must be our main object and not a secondary or supplemental one. This means, as it seems to me, that we must supply the materials and aids and favoring conditions for untrammeled observation, for independent induction, and for experimental verification, and that we must furnish suggestive models of the method of research. These things we must do with at least as much care, ingenuity, and precision as have been displayed in our efforts to transplant into the high school and to adapt in its work the methods, equipment and ideals of the university laboratory of morphologic research. I do not in the least doubt that by thus making possible some knowledge of this mental method and some general exercise of its application we shall be doing a great service to education and the state. For the method of science is not to be understood as a method for the scientific merely; it is to be taken as a general method of certainty. It is the only means of certain conclusion, over much the larger part of knowledge and experience. Even when the conclusions reached by it are themselves uncertain, it helps us to a certain knowledge of the degree of that uncertainty. It is the method of valid results in the objective world, of secure foundation for thought, of certain warrant for sustained and complicated action. To the practical man it is mainly useful in ordinary life as a measure or standard of certainty. He can rarely wait for its full and formal application to the small affairs of business, but must approximate its decisions as well as he can and take his risk of error as in the end the most profitable course, but it is extremely useful to him to have some means of judging what that risk may be; and in great affairs of business or of state, where expense of time, of labor, and of thought are justified by the gravity or the permanence of the interests involved, then it is the prime safeguard of enterprise, the promoter of welfare, a powerful instrument of progress. I think of it often as a simple but mighty engine composed of a few great bars and bolts, variously changeable in form and articulation, wonderfully adaptable to widely different purposes, fit to point a needle or to pound out a walking beam, by whose sole and sufficient aid the great builders of the past have reared the permanent framework of our civilization. To have one's hand on the lever of it with the knowledge of its mode of action and its powers is to be a modern man, equipped for modern life. To be ignorant of it or indifferent to it or contemptuous of it is to be exposed, helpless and unconscious of the need of help, to innumerable follies, quackeries, and superstitions ruinous to oneself and dangerous to society. To bring within the reach and privilege of the youths and maidens of the present day something of the knowledge and use of this great source of power, this is surely one of the serious obligations of the science teacher of the modern public school.

**Prof. C. W. Dodge**—The paper that we have just listened to was written by a man who has probably trained more working naturalists in the line of zoology than, I suppose, any other teacher in the country. It is rare that you come across a man who can take you out in the field and tell about the things in the streams and trees, and so on, who has not at some time or other either been a student of Prof. Forbes's or got a large part of his knowledge out of the contributions to the science which Prof. Forbes and his colleagues have made.

We should like very much to hear something on this subject from Dr Beal, who occupies the chair of botany at the Michigan agricultural college.

**Prof. W. J. Beal**—As I am to speak this afternoon, it is hardly just to present these points at this time. I was very much gratified in listening to the interesting paper of Dr Forbes, whom I have known a long time. I know of the men he has trained in this way, and I am glad to know how well we agree in some points. I congratulate myself on that. As I approve almost everything he said, I had better not take time just now to say anything more.

**Prof. C. W. Dodge**—Quite a number of allusions were made to the teacher of physics specially. May we hear from you on this interesting subject, Prof. Carhart? I think we are all pretty well agreed as to what the scientific method is, but we rarely hear it so plainly set forth as in this paper. We should be very glad to have you say something in the discussion of the paper.

**Prof. Henry S. Carhart**—I might offer the same excuse as Prof. Beal for not saying anything now, though I had not intended to discuss exactly this phase of the subject this afternoon. The president has well said that the general outline, as given by Prof. Forbes, of the scientific method is correct and exact. We all agree with him; and I have been very much interested in what he has said. Speaking for my own subject, particularly as applied to the secondary schools rather than the universities, it has seemed to me, while I was listening to the paper, that possibly there is a distinction to be drawn which was not drawn by the speaker, and which may perhaps throw a little light on the method of procedure in secondary schools. Prof. Forbes has outlined clearly and sharply the method which we must pursue as investigators—the method of scientific investigation. I do not think there can be any question about this at all, that an investigator must train himself to be sure that he as an instrument is properly employed, and that he must employ substantially the method that has been approved for a great many years by the best scientific inquiries. But in the secondary and public schools we have to deal with youths who are not investigators, who know nothing about science to begin with, and we can hardly expect to make investigators of them while they are in the secondary schools. I do not mean to say that they will not find out things they did not know before, through their own guided efforts, but the distinction I wish to make is perhaps between the teaching of science and scientific investigation—the methods to be used in the teaching of science, specially elementary science, and the method of investigation. There is a great deal of good to be obtained on the part of the student in the secondary schools studying science in an elementary way, in his verifying for himself well established laws that have come through investigations. Of course there are formulas in the book derived from investigations that the student can not repeat in full, but he can verify the laws that he learns from the book.

He must learn physical manipulation, because, whatever science he is engaged in, he must learn to use his own fingers, to use his own eyes, to draw his own conclusions. He should do that, though he simply verifies laws, and not everything should be pointed out to him. Of course suggestions may be given, but enough will be left of the unknown or the undetermined to make the subject attractive when presented to the learner or the beginner. He is finding out that he needs to learn, needs to cultivate his manipulative skill, to cultivate the power of observation; and another thing he will learn is that, however careful we may be, we can only approach in our scientific experiments more or less near to the goal which we set out to reach; that is, we shall find unavoidable variations in our results, coming partly from apparatus which may be imperfect, partly from the method, which the student may himself improve, and, above all, coming in part from the personal equation. Perhaps, if we view the teaching of elementary science from the point of view that it is the teaching of the scientific method rather than the method of investigation, we may have a little more good to say of the work that is done in elementary or secondary schools.

**Prof. C. W. Dodge**—Are there any others who have as valuable thoughts to give us on this subject, as we have just listened to?

**Prof. Frank M. McMurry**—I should like to put simply one question to Prof. Forbes. I should like to know to what extent he feels that this general scientific method is applicable to ordinary school subjects, even below the high school; whether or not the method is practically universal and ideal, and to be applied in geography or history or literature, as well as in science itself.

**Prof. S. A. Forbes**—I think it will be prudent for me to stay within the propositions of my paper and not to undertake to enter on the inviting but unaccustomed path which Prof. McMurry points out to me. I have merely attempted, under the instructions of your committee, to open the general subject, and shall be glad to leave the discussion of its details as affecting the various departments to the gentlemen representing those departments whom I see present in the audience, and whose names are on the program of this meeting. Indeed, from what I know of Prof. McMurry, I surmise that he has an answer ready for his own question.

**Prof. McMurry**—I rather believe that Prof. Forbes, himself, has thought a great deal about the matter; and I should like it, as a representative of public school work, if the scientists who believe in induction would urge it more as a general matter, because I think the public school teachers need it sadly. I do not know that you care to have that matter discussed.

I have one other question which I want to ask: Is this scientific method to be held before the student as his primary aim or is it the primary aim only of the teacher? And shall something else be the main purpose to the student, whether he be in the high school, in the college or in the grades?

**Prof. S. A. Forbes**—Of course, on a pedagogic subject relating to the work of the elementary schools, I can speak as a layman only, but it seems to me that the standards of the method of science should undoubtedly be kept in the teacher's mind as an elective and selective influence, and not usually given to the pupil. It might perhaps be stimulating to him, however, that he should occasionally be made to understand that he was working in the same field and to some extent by the same methods as the scientific investigator, exceedingly elementary though his work might be.

### Friday afternoon

## SECTION MEETINGS

## Section A. PHYSICS AND CHEMISTRY

### THE PLACE OF PHYSICS IN A LIBERAL EDUCATION

BY PROF. HENRY S. CARHART, UNIVERSITY OF MICHIGAN

The latter half of the century at whose very close we stand, has witnessed profound and significant changes in the materials which are used to impart a liberal education. The object aimed at remains, however, the same from age to age. The training of the intellectual powers so that the educated man can employ them with the highest efficiency in all positions calling for the exercise of his intellect, constitutes the chief object to be attained by study directed to purely mental ends. I do not wish to be understood as implying that moral training should be divorced from intellectual culture; but my theme deals chiefly with the intellectual rather than the ethical aspects of education.

The narrow curriculum of the college half a century ago has given place to the varied and differentiated university courses of the present. The sciences, though at first unwelcome guests, are now acknowledged members of the family circle. The modern languages have reached a position of higher esteem than formerly. The philosophy of history and the study of contemporary events have supplanted the old array of dusty facts and sanguinary battle records. Even in the primary schools the inspiring practice of waving the revolutionary "bloody shirt" in the faces of our British friends across the sea is happily becoming obsolete. The English language and English literature are now considered as worthy of study as the languages and literatures of peoples that long since ceased to be. Political economy and sociology are subjects of recognized standing and attract large numbers of students. Even philosophy, by a process of peaceful acquisition, has allied itself to science by including experimental psychology within its colonial domain.

Not only has the past half century witnessed an enlargement of the subject-matter of a liberal education, but a revolution has taken place in the methods of using educational material. Second-hand knowledge has taken a secondary place as compared with information gained at first hand. The sovereignty of the textbook has yielded to the sovereignty of nature. Knowledge by authority is giving place to knowledge by conviction. Museums with locked cabinets of natural history or of antiquities may be admirable objects to meet the demands of public curiosity, but they become educational appliances only when the student has access to their treasures and can study them by actual contact.

A significant change has taken place also in pedagogic practice. The method of investigation, as compared with mere memoriter acquisition, has been introduced with the serious study of physical science into our American universities. The experimental method adopted by science and its practice of original investigation have compelled other departments of learning to become its imitators. Even the classical languages now boast of their laboratory. Archeology has its workroom; language its photographs and lantern, its casts and reproductions of ancient life and times; while psychology has appropriated the apparatus of the physicist along with his methods.

50 years ago the laboratory method of teaching chemistry even was a novelty. It was not till a later date that physics adopted the same method and founded physical laboratories. The remarkable investigations of Regnault near the middle of this century were made possible at first by the appliances furnished by the Royal porcelain works at Sevres, of which he was the director, and later by the gift of English money. In England science was advanced by the enthusiastic labors of gentlemen of fortune, who devoted their time and money to this purpose. A fortunate combination of talents secured for England much scientific renown. Now every scientific department in a university is a constant contributor to the advancement of science. The scientific method and the scientific spirit have become general. In such an environment the place of physics in a liberal education is more readily ascertained than under the conditions prevailing in the middle of the century.

The first proposition which I wish to establish appears to be almost or quite self-evident. An education can not be comprehensive, free from narrow limitations, inclusive of the best things that go toward the making of a man, unless it comprises more than the time-honored humanities. It is unnecessary at this point to dilate on the humanistic elements in science, those features that connect it indissolubly with human interests, nor to depreciate linguistic and philosophic studies. But, if a study of the highest types of ancient literature gives an insight into the thoughts and feelings of the cultured past, and if it makes the student feel that he is allied to all that is most glorious in ancient history, so also does the study of history in the mother tongue have an equally emancipating effect on the mind. No one group of related subjects possesses the exclusive control of culture. If today the humanities should form a trust in their exclusive product of liberal culture, they could not control the output. The range of liberalizing studies has been greatly extended within 50 years. It is at the present time no less illiberal to contend that a liberal education is the exclusive function of the traditional subjects than to assert that it is the exclusive product of scientific study. The well trained, evenly cultured man is one who has laid a broad foundation for his specialized superstructure. Intellectual power is the prime object of education; but the power imparted by a single subject is usually specific and not general. Any study may have a tendency to fit one for special activities, but it rarely fits for activities in every direction. Hence the student whose intellectual diet is limited to the traditional menu may or may not acquire an easy, graceful and discriminating use of his mother tongue. It is of the highest importance that he should do so, but the study of mathematics and the classics chiefly or alone can never give mastery in dealing with the many-sided activities of life, in which language is not the most important factor. If to the traditional subjects are added science, civics, history and commerce, then more intelligent interest will be awakened, and power will be cultivated in other directions than those leading to the legal and clerical professions. The young man who has completed his general training with such a scheme of study, finds himself in harmony with his environment, when he enters active life, where he must make his own way if it be made at all. The student who gives almost exclusive attention to classical studies may succeed in getting in touch with the distant past; and, if he does, he will probably find himself out of touch with the present. Even a culture course should be broad enough to take in living human interests.

One of the decisive tests to be applied to determine the educational value of any study is the interest which it excites in the mind of the student. Judged by this criterion, physics claims a prominent place in every curriculum. He must be a dull boy whose interest is not awakened by the explanation of the most glorious and the most curious phenomena of nature. His enthusiasm is excited when he learns for himself that the events of the natural world are not fortuitous and incomprehensible, but are reducible to natural causes and are subject to the reign of law. This interest and enthusiasm are hightened by the knowledge that man has utilized natural forces and laws so as to produce the most beneficent results for the human race. He soon learns that invention follows discovery, and that the real pioneer is he who wrests from nature her secrets, and discovers the causes and relations of things. We are only just beginning to comprehend that Faraday in his laboratory in the Royal institution in London wrought a social and economic revolution by his discoveries of greater importance and more enduring than the political revolution of Napoleon, which only temporarily changed the face of Europe. Napoleon made and unmade kings as if they were puppets to do his bidding; but the slate of Europe which he made has long since been wiped off. On the other hand, the discoveries of Faraday have changed the civilization of the world within the last 30 years. And every decade only adds new applications of his discoveries, for they underlie every electric generator, motor and transformer. Electric lighting, electric railways, and the transmission of power, as at Niagara, are some of the beneficent results of Faraday's immortal discoveries. Yet there are some who tell us that the study of physics does not touch the secret spring of human interest and human activity with the same certainty as does the study of the ancient classics; that physics does not offer the persuasive attractiveness that inheres in the classical languages and literatures. Grant that physics appeals to the immature mind in a different way from the study of language; nevertheless, it appeals strongly in the hands of a live teacher, imbued with the dignity and interest of his subject. Testimony of parents is not lacking, that the first notable intellectual stimulus received by their children came through the study of physics. The taste for science is as natural as the taste for language, and both are necessary elements in a healthful intellectual diet.

Another element which should weigh in an estimate of the educational value of physics is the kind of training which physics furnishes. Its pursuit contributes to exactness of reasoning, of thinking, and of expression. Physics includes a great body of laws and relations which admit of precise quantitative statement.

The student of physics finds a subject which busies itself with the reason of things. Its business is to account for natural phenomena in the simplest possible manner. Causal relations are among the most prominent of those studied. An earnest study of physics, specially by the laboratory method, disinclines the student to rest on the authority of a textbook. He learns to try all things and to hold fast that which is good. Without losing respect for the opinions of others, he learns to discriminate for himself. In the laboratory he has ample opportunity to form independent judgments. His work contributes to the making of a man who not only knows but does. The student in practical physics "must acquire a certain technic, a deftness and certainty of touch, an ability to handle and adjust apparatus, which, however small it may seem to be in itself, forms one of the characteristic differences between the civilized man and the savage ". There is a close but almost indefinable relationship between manual and mental training. Manual dexterity begets mental agility. The refinement of the mind expresses itself in the refinement of manipulative skill. Trained fingers and a trained mind give the possessor a double claim on public appreciation. The artistic instinct and artistic appreciation do not make an artist. To these must be added dexterity with the brush, the pliable fingers, the mallet and chisel. Musical feeling expresses itself at the very finger tips. The hand is often as good an index of character as the face. The combined mental and manual skill cultivated in physical manipulation is no mean reward for the time devoted to it.

Physics has also other and perhaps higher motives. It considers not only the things which are seen, but still more the things that are not seen. If it has to do with many-sided matter, it has also to do with many-formed energy. The most important and most fascinating phenomena of physics are not the things one can see, but the invisible things that one apprehends only by the use of the imaginative faculty. It thus happens that the serious study of physics cultivates in no small degree the power of imagination. Force is invisible, though matter is its medium;

energy is invisible, and so difficult is its apprehension that even cultivated men fail to distinguish between it and force. An electromagnet is a simple electric device; but, when we contemplate its attendant magnetic field with invisible magnetic lines in the invisible ether, and try to picture to ourselves how energy is transmitted and transmuted through the agency of this invisible magnetic halo of gossamer threads, the imagination is taxed to its utmost capacity. Consider farther the fairy land of light, the audience hall of sound, the seething caldron of solar heat, or the appalling chill of liquid air, of interstellar space, or of the deathlike immobility of the absolute zero of temperature. Follow, if you can, the flow of radiant energy with the speed of light through boundless space, and tell us whether the Almighty, who let it fly, corrals it again and holds it in leash in some unknown rendezvous on the boundary of the infinite. The discoveries of physics outrun the imaginations of men. When the first report of Roentgen rays was bruited abroad, we received it with incredulity. That an exhausted glass tube, excited with electricity, should render visible the bones of a living man, and enable one to see the pulsating heart, was a unique fact lying beyond the realm of fancy even. Not less extraordinary were the discovery and measurement of Hertzian waves excited by the electric spark, followed by the marvelous application to space telegraphy. Discoveries often require the suggestion and stimulus of the imagination. Without doubt there is still worth unrecognized in the material things about us, which needs the touch of genius, aflame with the fire of imagination, to reveal. We need only call to mind "the ages during which men saw the kettle boil and the lightning flash without learning the worth there is in steam and electricity."

One more reason only do I need to give for the serious, contemplative pursuit of physics. By no means the least among educational values is the ethical aspect of a subject. The making of a man is seriously compromised by the lack of moral tone. Education that may cover the whole range of the intellect, and yet fail to produce seasoned moral fiber, is not entitled to be called liberal. Intellectuality divorced from morals is a misfortune to the individual and a menace to society. Judged by the ethical standard, physics is entitled to respect, not because it teaches formal morality, but because of the indirect yet powerful influence it brings to bear on the serious student. If it teaches anything, it emphasizes the reign of law. No shifting or pretense relieves him who sins against nature's laws.

Moreover, there is every motive of personal interest to honesty in the physical laboratory. The only object of the work is to find out the truth, and there can be no possible reason for preferring an incorrect result to a reliable one. Indifference as to what the result is to be, unflinching honesty in dealing with determinations, and patient revision and verification of values, are the ideals which are impressed on the student in the laboratory. When the law of the conservation of energy has been assimilated by the student, he will know that it is impossible in nature to get something for nothing. Whenever energy is concerned, an equivalent must be given for all we get. The physics student is always engaged in verifying old truths or in the discovery of new ones. Prof. Rowland says: "I value in a scientific mind most of all that love of truth, that care in its pursuit, more than any other quality. This is the mind which has built up modern science to its present perfection, which has laid one stone upon the other with such care that it today offers to the world the most complete monument to human reason."

I have briefly sketched some of the beneficial results to be expected from the serious study of physics. Have I drawn the outlines of an ideal pupil in an ideal school, and does the reality fall short of the ideal? Undoubtedly in many cases it does. Whether physics yields much or little depends first of all on the qualifications of the teacher. The solution of the whole problem rests with him. But this condition is not peculiar to physics. The same may be said of any subject of study. The classics and mathematics have had the training of teachers for centuries, and even these subjects often suffer at the hands of their friends. Till a very recent time it has been assumed that the classical graduate was competent to teach "any of the minor branches," as one of them expressed it, and that no special preparation for the important profession of teaching science was necessary. It is a matter of congratulation that in many localities at least normal graduates are adding university study to their preparation, and graduates with a bachelor's degree are returning to the graduate school to fit themselves for effective work as science teachers in secondary schools.

In certain university circles too much stress has of late been laid on the ability to investigate to the disparagement of the teaching ability. It is of vital importance to the teacher's influence that he should lead the way by his contributions to the science which he cultivates. On the other hand, it is no mean accomplishment to be a teacher of the best type. The teaching ability is as rare as the capacity for research. The good teacher lives in the hearts and lives of his pupils, while his researches may lie in the unwakened slumber of unread scientific transactions. Every teacher, even in a secondary school, should contribute something to his chosen science by way of device or invention or discovery; but he should first of all see to it that he does not neglect his preparation as an instructor. Joseph Henry in the Albany academy made discoveries in electricity that attracted the attention of the scientific world and established his fame. Read his own account of his experiments carried out during the summer vacation because he could not neglect his duties as a teacher. So careful was Faraday in his preparation for his lectures that he invariably tried every glass stopper in advance to assure himself that none were stuck in the bottles; and Faraday was a prince of experimenters and eminent in research.

The inspiring teacher is a treasure-trove. Like Topsy he is not made; he grows. But symmetric growth requires cultivation and nourishment. The teacher of genuine power is not one who turns to the profession as a temporary expedient. He prepares himself for his profession with conscientious fidelity. He must have a broad and catholic intellectual outlook, and should see other subjects than his own in proper perspective and dimensions. He must have the zeal of youth, the insight of maturity, and the wisdom of age. He must be enthusiastic himself, if he would arouse enthusiasm in others. He must first see clearly all around any topic before he tries to make it clear to his pupils. He must have warm human sympathies and be tolerant of mediocrity even, but he has no call to condone sloth. Devotion and diligence are the price of success. Continuous, persistent work conquers more difficulties than genius does. If the noblest prizes are for the great, many great rewards remain for the noble. If the pecuniary returns are not large, there are many compensating satisfactions. To help the deserving on the threshold of active life and to see one's pupils grow into places of power and public esteem are compensations for many personal losses.

No profession requires greater watchfulness as the years advance than the profession of teacher. Most of all, the teacher must see to it that he does not forget his own youth and so grow out of sympathy with the young. He needs to lay his course with care and to check it by frequent observations, lest he suddenly find himself far out of the intended path. To age it is permitted not merely to simulate youth, but to retain youthful feeling. The fir tree yields not its living, lustrous green to summer's sun nor winter's cold. When one reaches the period of the "sere and withered leaf," he should retire. He will never survive the "winter of his discontent" and revive with new bloom.

The teacher must also guard against overconfidence. He is exposed to peculiar temptations. He has to deal constantly with those who are not his equals in years and attainments. Hence the tendency to assume an air of authority and of confidence instead of the humility of mind that should characterize the teacher of science. It were better if he found himself frequently face to face with his peers. The stimulus of criticism from one's equals or superiors is a healthful tonic. Competition with mature minds favors sturdy growth. A large university has certain advantages over a small one in this respect. The number on the teaching staff is large enough to give room for the spur of competition and emulation among instructors. It is a mistake to assume that a poor teacher is more easily hidden in a large institution of learning than in a small one. The larger one is likely to make the larger demands. Where there are so many efficient teachers, it is more difficult for a poor one to maintain himself. Then, too, a large corps of instructors creates an atmosphere of work, an environment favorable to production. One must keep in the swim or sink. The modern American university is no cloister or refuge for the incompetent of other professions. It is a new world, a microcosm in itself. It is alive with ideas, enthusiasms, inventions, discoveries, emulations, awakenings to the higher intellectual life, the vivid foresight of brighter fields of thought, excursions into the boundlessness of space, or descents into the infinite underworld of the microscopically minute. It is in touch with the realm of thought the wide world round.

And what mighty movements have come forth from its doors in power during the past century! Scarcely a great invention of world-wide interest to humanity that has not seen its birth within walls devoted to education. Since the time when an undue respect for the learning of the past ceased to dominate the present, institutions of learning have become the sources of the most significant advances in ideas. Just at the opening of the century, Volta presented to the world the voltaic cell, and Davy produced the first electric light. A little later Oersted, in the University of Copenhagen, uncovered the relation between magnetism and the electric current, and so became the pioneer in electromagnetism. Then came Faraday with his mighty insight and his revelation of electromagnetic induction. Henry and Morse made the electric telegraph before the middle of the century; and Helmholtz exposed to view the law of the conservation of energy, which now dominates all science, pure and applied. Then Lord Kelvin taught masters of finance and promoters of international commerce how to use a submarine cable, and invented the instruments for it. Bunsen and Kirchhoff discovered the laws of spectroscopy, and set astronomers to investigate the composition of the stars; while Hoffman evolved new colors out of coal tar and revolutionized the industry of dyeing. Hertz discovered electric waves for future Marconis to utilize, and lastly Roentgen applied photography to a new and marvelous art, the value of which is not yet fully appreciated.

Finally, the teacher of science should strive to maintain serenity of mind. The modern university or secondary school is no longer a wooden bench with the pupils on one end and Mark Hopkins on the other. Teachers of great personality are as much a desideratum now as formerly, and as much in science as in the humanities. But science makes the more complex demands on the teacher. The intellectual and culture elements should be no less strongly developed than in other branches, while the mechanical sense and the cultivation of the fingers are essentials to success in experimentation and investigation. To the science teacher the library is as great a necessity as to the linguist or the historian; besides, he must always have his hand on the lever, ready to speed away on fresh excursions into new fields. To keep abreast of the present he is always reaching out into world-wide fields of information; to press forward into the unknown, he must catch time for thought and absorbing contemplation. All this makes a draft on his nervous energy but little appreciated by those whose daily round of monotonous duty does not open their eyes to the nature of such absorbing activities.

To be serene amid it all, to maintain one's health and composure, to expend the requisite energy and to retain enough for continued effectiveness and longevity, to grow old gracefully without losing touch with youth, to keep open the lines of communication, and to change one's point of view as the science silently changes with wider knowledge and clearer perceptions, is the problem confronting us who love our work and are devoted to the advance of our favorite subject. Is it too much to ask that governing boards consider these demands in determining schedules of work, and that they leave a little time for the teacher to cultivate moderation, composure and serenity? Then may he appear

> Like some tall cliff that rears its awful form,
> Swells from the vale and midway leaves the storm,
> Though round its base the rolling clouds are spread,
> Eternal sunshine settles on its head.

## DEVICES USEFUL FOR DEMONSTRATION PURPOSES

### (Abstract)

BY PROF. EDWARD L. NICHOLS, CORNELL UNIVERSITY

I have often urged at these meetings the desirability of devoting a portion of our time to the consideration of practical physics, and it is for that reason perhaps that I have been asked to set the example today.

The devices to be described are not altogether new, and they are of a very simple nature. For their simplicity I have no apology to offer, it being a first principle of experimental demonstration that the apparatus should be shorn of every unnecessary feature which might distract the mind from the contemplation of the phenomenon to be exhibited or bewilder the student in his attempt to grasp the principle to be illustrated.

### *1 Apparatus for showing, in a semi-quantitative way, the expansion of air at constant pressure*

In exhibiting the phenomenon of the expansion of gases by heat, it is desirable not only to afford the most direct possible ocular demonstration that expansion occurs, but likewise to show approximately how great that expansion is. The ordinary form of air thermometer fails in the latter respect, because we are unable to estimate even approximately by inspection the relation of the total content, including bulb and neck, to the volume of the mercury displaced in the process of expansion. In a cylindric vessel the volume is, however, directly proportional to the length of the cylinder, and the change of the volume between the ice point and the steam point ($\frac{100}{273}$ of the volume at 0) is so great that it can be estimated with the unaided eye. In the apparatus which I have adopted for the purpose after trying a

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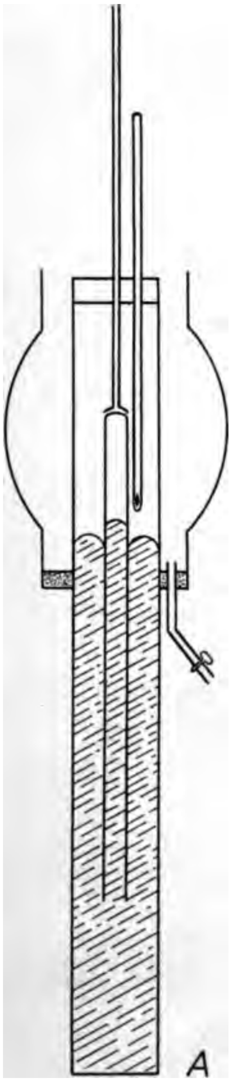

Fig. 1.

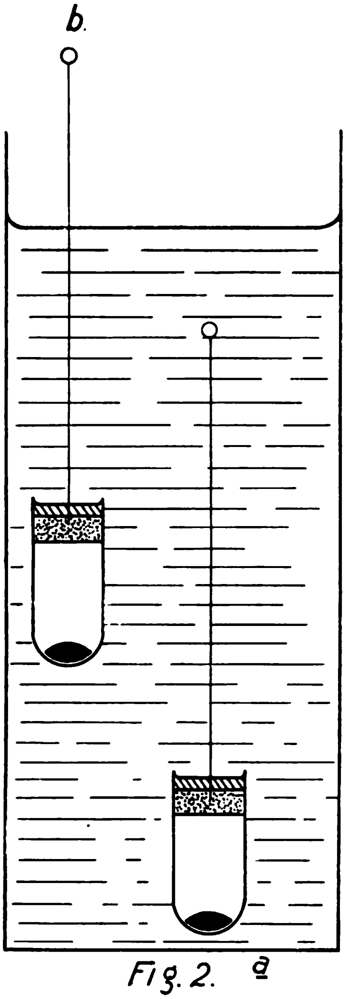

Fig. 2.

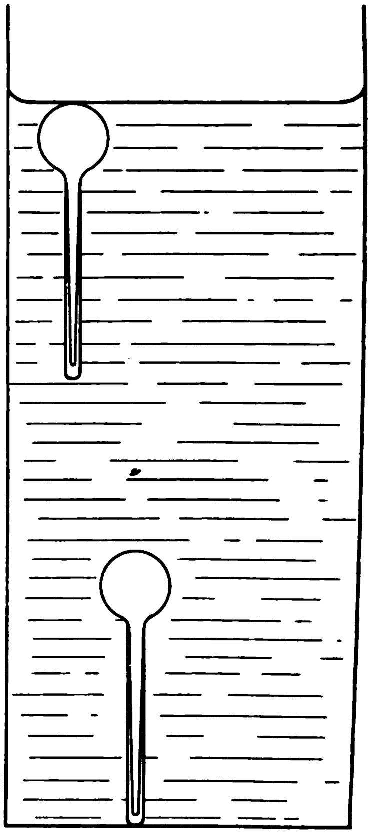

Fig. 3.

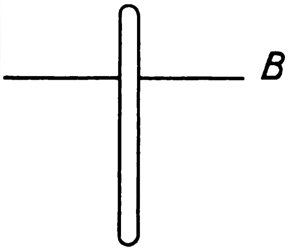

Fig. 4.

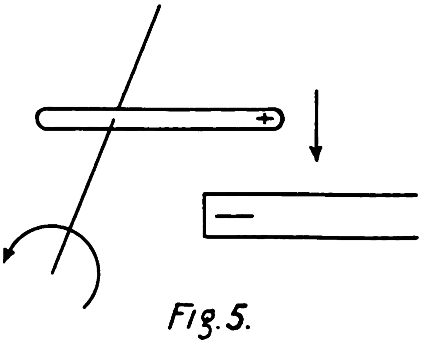

Fig. 5.

variety of forms, the very ingenious and simple device employed in the usual experiment for demonstrating Boyle's law is used. A tube 100 cm long and about 5 cm in diameter is closed at the lower end and two thirds filled with mercury (fig. 1). A small tube, likewise closed at one end, and graduated in cubic centimeters from the bottom upward, is inverted in this mercury cistern as in the usual Mariotte apparatus. It is convenient to select for this purpose a tube the total contents of which are 100 cc. Such tubes already graduated may be purchased of any dealer in chemical apparatus. If the amount of air intrapped in the upper end of this inner tube be such that, when the tube is pushed down so that the hight of the inner column of mercury is at the level of mercury in the outer cistern its volume is 27.3 cc at zero, the apparatus becomes direct reading. To adjust the pressure of the inclosed gas to exactly one atmosphere, a rubber cork is fitted to the open mouth of the larger tube. Through a hole in this cork a tube slides with sufficient friction to hold it in position at whatever point it may be released. The lower end of this sliding tube is enlarged in the blowpipe flame into the form of a small inverted cup. Within the hollow of this little cup the top of the tube which floats in the mercury is placed. The floating tube will then stand vertically in the center of the cistern, and its hight can be adjusted with ease so that, whatever may be the temperature, the mercury columns inside and outside of the tube will coincide. I know of no more simple or satisfactory method of maintaining the inclosed gas at a constant pressure of one atmosphere. To bring the inclosed volume of air to the temperatures, 0°C. and 100°C., an ordinary lamp chimney of the largest size is mounted so as to surround the entire upper portion of the outer tube as shown in fig. 1. The space between this lamp chimney and the outer tube may then be filled with water and crushed ice or a jet of steam may be introduced to bring the inclosed parts to a higher temperature.

In using the apparatus for classroom or lecture demonstration it is well to start at the steam point. The apparatus having been previously set up and steam introduced for some little time before the beginning of the hour, the inner tube will have already attained the proper temperature when attention is first called to the subject. The inner tube is raised so that all may see the mercury column above the level in the mercury in the outer cistern. It is then lowered by pushing down the sliding tube till the pressure is exactly one atmosphere, and the hight of the column is read on the graduated scale. The steam jet is now removed, and the space between the outer tube and the chimney is filled with ice water. The mercury column within the inverted tube will soon be seen to begin to rise above the outer level. The apparatus is left standing while other topics to be presented to the class are considered, and just before the end of the period, the final adjustment is undertaken. The diminution of volume due to fall of temperature having been pointed out, the sliding tube is then pushed down till the pressure is restored to normal, when the reading on the graduated scale is again made. For the purpose of drawing off the condensed steam and likewise the water from the bath, it is convenient to insert through the collar on which the glass chimney is mounted a small tube with stopcock, as shown in the figure. A siphon may however be employed for this purpose. Another convenient addition to the apparatus is a thermometer inserted through a hole in the upper cork, by means of which one can ascertain when the change of temperature is completed. Successful working of this apparatus depends of course on the use of dry mercury and a perfectly dry inner tube. To secure the very best results, the graduated tube should be completely filled with mercury before inverting in the cistern and air-dried, by passing through strong sulfuric acid or through drying tubes with potassium oxid, or phosphorous pentoxid should be introduced by means of an inverted siphon. If these precautions be taken, the apparatus will serve very well for quantitative laboratory work on the coefficient of expansion of air, though of course it is not possible to make readings to the degree of exactitude that may be obtained with more refined apparatus.

### 2 *Floats adjusted to show the phenomenon of the maximum density of water*

The fact that water reaches its maximum density at 4°C. is of course touched on even in our most elementary courses of experimental physics, and various forms of apparatus have been suggested for the purpose of showing this phenomenon. The simplest of these consists of a float, like that suggested by Preston in his well-known work on the theory of heat[1], so adjusted that it will float in water at 4° and sink in water at zero. Such floats may be given various forms, one of which is shown in fig. 2(a). This consists of a short piece of light glass tubing, preferably the bottom of an ordinary test tube, to which a cork is fitted. This cork should be of such size that it can be pushed down into the tube by slight pressure. The first approximate adjustment is made by pouring mercury into the tube till it will float nearly submerged in water with the cork inserted. A long, thin stem consisting of a fiber of glass not more than one half millimeter in diameter is now inserted vertically through the center of the cork, and the tube is sealed by the application of a layer of cement (bicycle tire cement or ordinary sealing wax). On placing the float thus prepared in water at 10°, it will be found either too heavily or too lightly loaded. In the latter case farther adjustment is possible by pushing the cork more deeply into the tube, thus decreasing its displacement, till it will sink. The final adjustment, which consists in lightening the tube as far as is possible without actually enabling it to float, is performed by melting the tip of the glass fiber in a Bunsen flame and removing small portions of the melted glass. If too much is removed, a still smaller amount may be restored in a similar manner. If this float be adjusted so that it will sink very slowly in water at 10°, it will do the same at zero, because the density of water at these two temperatures is almost identical. It only remains to determine whether the adjustment is close enough to admit of its rising at the intermediate temperature of 4°. When we consider how small the change of density is between these temperatures, a unit of volume of water at zero diminishing to .99988 at 4° and increasing again to 1.000125 at 10°, it would seem at first hopeless to attempt to make such an adjustment. A little practice will show however that by successive alternate additions to and curtailment of the length of the glass fiber, the float may be brought to fulfil these delicate requirements. It will stand at the bottom of a cylinder of ice cold water, will rise slowly as the temperature approaches 4°, and, if care be taken to see that it is not permanently retained at the surface by the action of the surface film, it will sink again before 10° has been reached.

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[1] Preston. Theory of heat, p. 177.

Another plan, likewise easily carried out, consists in so adjusting this simple instrument that it will float with a portion of the slender stem projecting through the surface volume at 10°. (*See* fig. 2(b)) In this form the instrument becomes an extremely sensitive hydrometer of variable immersion, and its upward and downward movement between zero and 4° and between 4° and 10° will frequently amount to 2 or 3 cm. In this form the apparatus lends itself to the actual measurements of the change of density of the liquid.

To both of these forms the following objections may be urged: in the first place, they are exceedingly fragile and in the second place, one never feels sure that the closing of the tube by means of the cemented cork is complete. The slightest leakage or the soaking of water into the cork through a layer of cement would speedily destroy the delicate balance of the instrument. On this account a float entirely constructed of glass and containing no mercury is to be preferred. A piece of ordinary glass tubing, having a bore of about 2 mm, is sealed at one end and is blown into a bulb about 6 or 8 mm in diameter. The tube is then drawn out in the flame of the blast-lamp at a point about 5 cm from the bulb and sealed off (fig 3). This closed tube is now placed in water at 10°. If it floats, more glass is added at the closed end till it sinks, and successive adjustments are made by adding to or subtracting from the amount of glass at the heavy end till it sinks very slowly indeed at that temperature. In order to save time, it is best to make two of these floats, adjusting the one in the flame while the other is cooling. It is not a long nor particularly difficult operation to adjust such floats, and they have the advantage of being permanent. After adjustment they may be placed in a bottle and will serve for a lifetime. For the purpose of demonstration it is only necessary to place the bottle in a bath of crushed ice or melting snow long enough to bring the contents into the neighborhood of the ice point, and then to place the bottle on the lecture table and allow it to warm up gradually in the atmosphere of the classroom. The bulbs, which at the beginning of the experiment are at the bottom of the bottle, will then rise and, after the liquid has passed the temperature of 4°, will sink slowly again to their original position.

### *3 Torsion balance electrometer*

The gold leaf electroscope is an instrument of such simple construction and of such delicacy that it answers the purpose of indicating the presence of static charges of electricity and likewise of determining their sign, in an admirable manner. There is however nothing quantitative about the action of such electroscopes in the ordinary form; and, when we come to the question of measuring differences of electrical potential, the usual forms of electrometer are somewhat expensive to construct and difficult to handle. In the instrument now to be described I have endeavored to apply a principle already used by Threlfall for the measurement of the force of gravitation. Consider the case of a short rod mounted with freedom of rotation about the horizontal axis AB (fig. 4). Its position of unstable equilibrium will be that in which the longer end of the rod is vertically above the axis of support. If now such a rod be fastened, at the point where the axis in the figure lies, to a horizontal fiber of quartz or to a fine wire, one end of which is fixed while the other is capable of being twisted by means of a micrometer screw, the twisting of the fiber will gradually lift the suspended bar with a motion of rotation out of its vertical position of stable equilibrium. The position of unstable equilibrium will no longer be vertical, but will make some angle with the vertical plane, depending on the stiffness of the fiber and the mass and adjustment of the rod. Finally, as the torc increases, the angle of instability is reached and the equilibrium of the rod is converted from the stable to the unstable type. At the position at which this change is approached the sensibility of the rod to forces tending to turn it on its axis, increases indefinitely; so that by means of this device a torsion balance may be constructed, the sensitiveness of which, like that of the ordinary balance, may be increased at will up to the point where it is no longer possible to make it return to its zero position. By a suitable adjustment of the bar this position of maximum sensibility may be made to occur when the bar is in a horizontal plane (fig. 5), and, if the longer end of the bar be given a metallic coating and be charged, we have an instrument which may be used as an electroscope. By attaching to the short end of the bar a mirror so that its angular movement can be carefully observed and by using the micrometer screw at the torsion head to bring the bar back to its zero position, the instrument becomes an electrometer. The degree of sensitiveness to which an instrument of this type can be brought may be readily imagined. Threlfall found that, with the form which he gave to it, he could measure variations in the force of gravitation which did not amount to more than one part in a million. I am experimenting at present to see whether it be not possible to construct a manageable balance of this kind which will show the gravitational traction of bodies for one another. An apparatus which will do this and which is easily handled in the classroom would be of course a desirable addition to our equipments for demonstration. The principal fault which torsion balances of this type possess consists in the lack of sufficient damping. Whenever they are drawn out of the position of equilibrium, they oscillate for a considerable time before coming to rest. Even if we are not able to overcome this fault, such balances will be useful in many ways. With them we may exhibit and compare magnetic attractions and repulsions by substituting for the charged body at the end of the rod a thin disk of iron. By placing vertically beneath this disk a coil of wire, one may readily convert the apparatus into a sensitive ammeter.

In seeking to increase our means in illustrating the principles of physics, it is often better to endeavor to find new applications of existing apparatus with such modifications as may be necessary than to attempt to devise something entirely novel. This is the method of procedure which I have followed in the present paper, and the examples might be indefinitely extended. Take for instance, the revolving mirror devised by König for the study of the manometric flame. This may be used in a large number of other striking experiments, by means of which the complex character of the electric spark may be shown, curves obtained from the composition of two vibrations either parallel or making any desired angle with one another may be exhibited. The periodic extinction of the alternating arc or the movements of such an arc in the magnetic field may be studied, etc. With another well-known and very simple instrument, the revolving disk with open sectors, innumerable fleeting phenomena may be exhibited. Prof. Boys for example used this device for showing the nature of the action of sound waves on sensitive water jets. It is equally applicable to the observation of the changes of form of falling drops, the study of vibrating rods and strings or the mapping of the paths of projectiles. In all such work the aim should be to secure the greatest simplicity of construction compatible with the satisfactory operation of the instrument.

## Section B. BIOLOGY

### TEACHING PHYSIOLOGY IN SECONDARY SCHOOLS

BY PROF. FREDERIC S. LEE, COLUMBIA UNIVERSITY

It is a pleasure and privilege to meet the members of this association. I am sure that you have much valuable knowledge to impart regarding the teaching of physiology in secondary schools, and I have come to be instructed; to receive rather than to give. I shall make certain suggestions, but shall hope that you will make more, and that at the end of our discussion I shall feel a much greater familiarity with my subject than I now feel. I sometimes think that, of all teachers, we who teach physiology, whether in the colleges or in the secondary schools, are a very good-natured folk and most courageous, for we are opposed in so many, so diverse, and so unique ways. The cruelty of the anti-dissectionists and the anti-vivisectionists is notorious. They abuse us for what we do, and they would force us to teach the science of life without recourse to the things of life. The anti-alcoholics and the anti-tobacconists say that we drink and smoke, and they would compel us to subordinate all our instruction to the demands of an intemperate temperance. The parents, forgetting that man is divinely made, say that whatever is inside his body is unclean, and a knowledge of it is improper, and they do not wish the minds of their sons and daughters to be corrupted. Against all these we must contend; and happy is he who can retain the sweetness of his spirit and the sanity of his teaching. Yet, in spite of all these, the character of instruction in physiology in both the secondary schools and the colleges has steadily improved, more slowly perhaps than in other sciences, but still it has steadily improved, till it now approximates that of chemistry and physics and zoology and botany. We are now in the midst of a specially rapid part of our progress, and it seems to me well to be sure that we know our compass points and direct our course rather than drift with chance currents. Hence I wish to talk over with you today what our course should be and how we can best direct it. Let us consider, in the first place, the question of what we shall teach.

I have long felt that we have been looking at our science from too narrow a standpoint, and that this is in great part responsible for the slow betterment of our teaching methods. We have confined ourselves to the physiology of the human body, forgetful of the fact that, wherever living substance exists, there is physiology. To me physiology is the science of the living process, the science of life itself, of vital activity, not passivity, of vital dynamics, not statics. It deals with living matter, not with dead or non-living matter. It is altogether secondary whether the life and the living matter occur in a man or a monkey, a vertebrate or an invertebrate, an exogen or an endogen. If the life is there, there is physiology. Is it not a fact that few teachers impress this view on their pupils? The latter learn, as one pupil expressed it to me, that "physiology is all about your bones and stomach and liver and heart," that is, the word, physiology, suggests the human body only. In the textbooks we constantly find in use the term, "the body", as if there existed no other body than that of man. This use of the word, body, always suggests to me a limited recognition of the scope of our science. It is true that the science developed historically as a science of the human body, and the anthropocentric idea has prevailed among biologists till very recent times. But, thanks to the discovery of protoplasm as the physical basis of life, the formulation and promulgation of the evolution theory, the consequent idea of the essential unity of life, and the resulting wonderful advance of biology in general, the fact is now evident to biologists that physiology is a science that should far transcend its former human boundaries and be synonymous with the science of the vital process itself. The word, physiology, should be associated with the body of man no more than with that of other organisms, animal or plant. There is a physiology of the frog, of the earthworm, of the amoeba, of the mold and the flowering plant, as there is a physiology of man. This is clearly recognized in the admirable book, *Practical biology* written by the president of this association, Prof. Dodge. It may be said that all this is very true, but why attempt to cover so wide a field in teaching the subject in secondary schools? My reply would be, because I believe that with most pupils the broader conception is far the more interesting one, that it obviates the feeling of repugnance with which not a few pupils approach the study of physiology, and it tends to prevent the development of a feeling of self-consciousness, for which the contemplation of the human body alone may be responsible. I think that the last-mentioned point indicates a real danger, which has not been sufficiently considered by teachers. Whenever there preexists a tendency toward the consciousness of self, the concentration of one's thoughts on the phenomena of one's own body can be only detrimental, and a pronounced self-consciousness is one of the greatest handicaps in the struggle of life. The broader conception of the scope of physiology would make the pupil regard his own body not as unique, but as one of many.

Furthermore, the words of the pupil already quoted give a clue to another false conception on the part of most pupils and, I fear, many teachers. "Physiology is all about your bones, and stomach and liver and heart," that is, all about the organs of the body. Now we all know that the organ is but one kind of bodily component, but one unit in the successive stages of analysis of the structural composition of a body. There is the body or organism; this is composed of organs; the organ is composed of tissues, and the tissue of cells. There are thus four structural units of different grades. We are prone not to recognize the fact that each unit has its physiology. All that the organism as a whole does constitutes the physiology of the organism; all that each organ as a whole does constitutes the physiology of the organ; and so with each tissue and each cell. The one thing that is the basis of all these is the living substance, protoplasm, and it is the vital process of protoplasm which is the basis of physiology. I think this last fact can not be too strongly insisted on. We do not sufficiently impress it on and into the minds of our pupils that there is a living substance, something distinct from non-living substance; that this permeates and is the essential part of all organs, tissues and cells of all organisms; and that all vital phenomena are simply the expression of the living of this living substance. I am quite aware of the fact that the boundaries between the living and the non-living are not sharply drawn; and, if I were asked to give an exact definition of living substance as distinguished from non-living substance, I would be forced to confess my inability to do so. But this need not obscure the facts that in the minds of all biologists the two conceptions of the living and the non-living are justly separate, and that each represents a distinct entity.

I have spoken of the physiology of organisms, and it may be well to dwell for a moment on this point. By this term I mean to include all the activities of the individual considered as a whole, in distinction from the activities of the parts of the individual. It signifies, in other words, the relations of the individual to his environment, and it constitutes what may be termed external physiology, in distinction from the internal physiology of the organs, tissues and cells. 30 years ago Haeckel made a similar division of the subject-matter of the science, employing the terms, "the physiology of relation," and "the physiology of conservation." External physiology would include much that was formerly included under the term, "natural history", such as mode of life, habits and instincts, life histories, the many and varied relations of individual to individual, and of animal to plant, the events of daily and seasonal life, and a host of allied phenomena. External physiology would thus include much that is now comprehended under the term, "nature study", and it is an interesting fact that this modern term, "nature study", is an almost literal translation of the word, physiology (Greek Φύσις and λόγος)." A very early, if not the original sense of the word. Φύσις, and the sense in which it is at times used in the Homeric poems, is that of living nature; and it is the living of nature to which we should go back in our conception of the science. It is a practical impossibility to draw a sharp line between internal and external physiology, for there is hardly a single vital activity within the organism that is not plainly dependent on the relation of the organism to its environment.

The second point that I would make is the desirability of distinguishing carefully between anatomy, or morphology, and physiology, and making the pupil understand and appreciate this distinction. The average course which goes by the name, "physiology," is a hodge-podge of anatomy, histology, physiology and hygiene, and the pupil rarely understands the distinctions between these various sciences. These distinctions should be clearly appreciated; and I am glad to say that they are made sharp and clear in the *Elementary biology* of Prof. Dodge, to which I have had occasion to refer. Moreover, and what is of more value, the idea of physiology proper should be kept paramount, and anatomy and histology should be introduced only in so far as they illuminate the former. To me an anatomic fact in itself is of little importance. It becomes of immediate interest, however, if it be correlated with the idea of function, and I think it not improbable that this is the experience of most individuals. This leads me to recall to your mind what Huxley has said of his own scientific bent. I quote from the very charming *Life and letters*, which has recently been published by his son. Referring to his early medical studies, he says: "The only part of my professional course which really and deeply interested me was physiology, which is the mechanical engineering of living machines; and, notwithstanding that natural science has been my proper business, I am afraid there is very little of the genuine naturalist in me. I never collected anything, and species work was always a burden to me; what I cared for was the architectural and engineering part of the business, the working out the wonderful unity of plan in the thousands and thousands of diverse living constructions, and the modifications of similar apparatuses to serve diverse ends." This curiosity regarding the work of living machines is widespread, yet most elementary textbooks of physiology are burdened with needless anatomic and histologic details, and too often these burdens are transferred to the pupil to lumber his mind. This is specially conspicuous in the study of the brain. Here, where knowledge of function is sadly lacking, its place is taken by innumerable and intricate details of structure, the significance of which neither the teacher nor the pupil understands, and which the latter must commit to memory, as the former did before him, merely as isolated brute facts. If physiology were merely a memory science, such criticism would be uncalled for. But it is not a mere memory science. It is a science not of observation only, but preeminently of experiment; and, because of this fact, above all other biologic sciences it develops the reasoning powers. Where there are such splendid opportunities of studying the relations of cause and effect, we as teachers are not using our highest privileges if we neglect these opportunities, and confine our efforts to the cramming of the pupils' minds with undigested, unreasoned and unappreciated anatomic facts.

In thus urging the maintenance of a distinction between anatomy and physiology and the use of the former only as an aid to the latter—a subject to which I shall have occasion to refer again—I have introduced a third point in the matter of what we shall teach, and that is, that in the selection of subjects to be taught we ought to be governed by a proper sense of proportion. The customary selection, as made by the writers of the textbooks, is not altogether a good one. As has been already intimated, the textbooks confine themselves too closely to internal physiology, and contain needless anatomic detail. Furthermore, it has become the habit among the textbook-makers to magnify out of all proportion to their value certain matters which are not simply anatomic. Take, for example, the fact that is usually made so prominent, that bones contain animal and mineral matter in certain proportions. I venture to assert that as usually taught this is a mere matter of memory for the pupil, the real significance of which he does not at all appreciate, and this is so even if he sees the decalcified fibula tied up in a knot. The terms, animal and mineral, are Greek to the pupil. If he could be made to know that a bone is composed of living substance and non-living substance, arranged in certain definite ways, that it subserves its chief function as an organ of support or protection by reason of the superabundance of its non-living substance, and that its living substance, relatively minute in quantity, is present for nutrition and growth and repair, he would appreciate the value of an understanding of the composition of bony tissue. Take again the facts of blood pressure: even in elementary textbooks these are often stated at length, while the significance of the facts in regulating the supply of blood to the various parts of the body is altogether subordinated or lost sight of. In many of the larger textbooks the details of blood coagulation are rehearsed at a length out of all proportion to their value as elucidating physiologic processes. In these various cases it happens too often also that the pupil is lost in a maze of detail, and fails to see the principles that should be brought out; he can not see the wood for the trees. For my part, I would bring all subjects, such as those mentioned, the anatomy of the brain, blood pressure, the coagulation of blood—and the list might be greatly enlarged—down to their lowest level of detail, and this level should be that which is necessary to a comprehension of the functional uses of the parts or phenomena in question.

So much for the question of what we shall teach. Now how shall we teach it? First, whatever is taught and whatever methods are used in the teaching of it, it should be taught as a science still in the process of making. The sum of physiologic knowledge is being increased every day. I speak of this point with special feeling because it was my unfortunate experience in my introduction to the study to be taught differently. I was first taught physiology as I might have been taught, as I was taught, Latin and Greek—as something that is completed, dead. The idea was never given to me that there existed at that day working physiologists, and busy physiological laboratories, where men were constantly pushing out into the unknown, discovering new facts, overturning old theories and advancing new ones, that there existed numerous journals devoted to the publication of the results of original researches in physiology alone, and that the progress of the science was so rapid that it was quite impossible for one to keep pace with it in all its features. If physiology is the science of the living, it should be taught as a living science. In my experience there is no way in which a student's interest in a subject may be more effectively aroused than by making him realize that the subject is still in an uncompleted state, that discoveries are still to be made in it, and that some of these discoveries are just as possible for him as for any one else. Most elementary textbooks err in this respect, that they are not willing to say that anything is unknown, and it not rarely happens that teachers, from a false sense of pride, attempt to assume a knowledge where knowledge is not. We all know how fatal in the long run is this attitude. Prof. Pearson has well said: "We must accomplish a task more difficult to many minds than daring to know. We must dare to be ignorant." There is much more that our science has yet to acquire than it now possesses. Let us be at least as modest as our science.

Now more specifically as to the method that we should use. Here is to be found the most marked evidence of the progress in physiologic instruction of which I have spoken. Strange as it may seem, only comparatively recently has physiology been recognized in its methods of instruction as one of the natural sciences. The textbook has been too long the one source of knowledge. But now the teachers have become enlightened, and practical physiology has come to stay, even in secondary schools. In all divisions of our subject either practical work on the part of the pupil, or demonstration by the teacher, is now a necessity. The days when the only object lessons that the pupil received were those that could be learned from the human skeleton borrowed from the village doctor are happily passed. Practical physiology has emerged from that stage of ossification. And it is now becoming, what it should have become long ago, a matter of things and not words. There is no stronger evidence of the reality of the practical phase of physiologic instruction than the fact that, while 10 years ago good directions for the practical teaching of physiology did not exist in print, now almost every elementary textbook contains directions for laboratory work either for the teacher or for the pupil, and not a few special books in practical physiology are appearing. The elementary textbooks with directions for practical work are innumerable and need not be severally mentioned here. Of the specially practical books those of Mr Peabody of the Peter Cooper high school, New York city, and of Miss Brown of the state normal school, Hyannis (Mass.), are both excellent. They cover the customary elementary ground with a fair degree of fullness, and they have the great merit of requiring the pupil to "study nature, not books," as the elder Agassiz so epigrammatically put it. Strange as it may seem, it is not every laboratory handbook that follows this wise injunction. While professing to guide the student in his study of nature, too many contain and impart the information which nature lying on the laboratory table waits to give. The student learns from the book, and looks at the specimens to see whether nature has learned her lesson and has actually produced what the book says she should have produced. Lamentable as this mode of teaching is, happily it is rapidly being replaced in physiology, as in the other natural sciences, by the more rational method of directing the student's attention by skilful questions to the object before him and making him learn from nature herself the laws of nature. The ideal method then is for the student himself to do the practical work and obtain the mass of his knowledge by its aid, and poor indeed is the school in which this can not be done to a considerable extent. Such poor schools do exist, but in the majority of cases their poverty consists mainly in the lack of energy on the part of the teacher. Whatever the cause, it does sometimes happen, however, that practical work by the pupil is an impossibility. In such case, recourse should be had to careful demonstrations and demonstrative talks by the teacher, and these can be made of very great value, either as the sole object method of instructing or as an adjunct in the study of complicated phenomena, where the simpler ones are dealt with by the pupil himself.

In thus advocating the wide use of the object method, I would not be understood as decrying the textbook. Prof. Minot has said: "The practical work is the instructive work; it is the source of real knowledge. The actual direct contact with the objects and with the phenomena *is* knowledge." And then he adds with humorous exaggeration: "Knowledge lives in the laboratory; when it is dead we bury it, decently, in a book". In considering how literally these words are to be taken, it might be well to bear in mind that in his great work on human embryology, Prof. Minot has himself given to the world one of the finest specimens of dead knowledge that exists in modern scientific literature. Notwithstanding the preeminent value of the practical work, the textbook has justly a very real place in elementary scientific instruction, if for no other reason than that it serves as a convenient compendium of what may be learned from the object, and enables the pupil to fill in the gaps that, with the best laboratory instruction, are necessarily left in his knowledge of the subject. In all cases, however, the pupil should be made to feel that the book is secondary; that nature, not the book, is the thing to be learned.

In applying these general ideas now to the case before us, the teaching of physiology, I wish to emphasize again the fact that anatomy and physiology are two separate and distinct sciences. A knowledge of anatomy is a prerequisite to a knowledge of physiology, but it can never be made a substitute for the latter. Function can not be inferred with accuracy from structure. The truth of this is abundantly evident in the long history of physiology, and no concrete example is more striking than that of the discovery of the circulation of the blood. To us the facts of the circulation are so familiar and appear so obvious that, at first thought, it is difficult to realize that they needed any discovery at all, much less that such discovery extended over some two thousand years. Physiologic observations on the living organism were comparatively few before the Christian era, and up to this time all ideas of the functions of the heart and the blood vessels, which were derived mainly from dissection and the observation of conditions in dead animals, were crude and fantastic. According to Aristotle the heart is "the source and fountain of the blood, and its prime receptacle;" it is "the seat of vitality, in which the blood receives its final elaboration and its impregnation with animal heat." The blood is concocted continually in the heart and passes thence continually along the blood vessels to the periphery (no difference in function being recognized between arteries and veins) and at the periphery it is disseminated by exudation throughout the substance of the body, there supplying nutriment, and being continually consumed, but never again returning to the place of its origin. The beat of the heart is due to a momentary expansion within it resulting from the heat of the blood, a boiling in other words, and the pulse in the arteries is a resultant of this cardiac ebullition. A certain Hippocratic writer, a little later than Aristotle, whose name is unknown, added a little experimentation to his dissections and rightly recognized the semilunar valves as valves, but he interpreted their function to be that of preventing the contents of the arteries, which have been laden with gross food and drink from the stomach, from returning to the ventricle and defiling the intelligence which there resides. Other anatomists, on dissecting the body, naturally found the arteries empty of blood, and the idea arose and prevailed for hundreds of years, and was taught even by the famous school of Alexandria, that the arteries during life contain air in a refined form, the vital spirits, the veins alone containing the nutrient fluid. The vital spirits were derived in some obscure way from the air taken into the lungs in inspiration. They passed thence to the heart and through the arteries to all parts of the body, maintaining the heat and inducing the vital phenomena exhibited by the various viscera. It was Galen, in the second century of the Christian era, who, by a simple experiment showed how erroneous was this long prevailing deduction from anatomic facts as to the function of the arteries. By simply tying an artery in two places in a living animal and thus imprisoning the blood, he demonstrated the fact that these vessels during life contain blood, not air. Yet, after this seemingly pregnant discovery, Galen had no conception of the blood circulation. For him, as for his predecessors, the importance of the heart consisted largely in its being the center of organic life, the source of the vital heat and director of the vital actions; it dilated to draw into itself the vital spirits from the lungs and it contracted to discharge spirituous blood to the periphery. So too the arteries actively dilated to attract spirituous blood—and this dilation constituted the pulse—and they contracted to discharge their contents. After Galen came the long night in the history of science, the 1300 years of the middle ages, when physiologic experimentation and hence physiologic progress were at a standstill, and Galen's system with its curious mixture of truth and error prevailed. For still another hundred years after the dawn of the scientific renaissance did men struggle with the problem of the circulation. They proved Galen's anatomy often mistaken, but they accepted his physiology and expended much energy in speculating as to the mode of working of the mechanism whose structure they were gradually learning. And then came the immortal Harvey, who did not decry anatomy, but studied structure for the purpose of mastering function. He observed the living, uninjured organism; he performed vivisections; he altered conditions; he attacked old doctrines fearlessly; at every step he experimented, experimented, experimented; and in 1628 the world received the truth as it is in nature, as it is known today and as it will be known for all time. Physiology is the science of the living process, and the discovery of the living process is not to be brought about by the contemplation of dead anatomic material.

This leads me to the consideration of one of the most common methods of physiologic instruction, namely, that of dissection of dead organisms, organs, or tissues, by either the pupil or the instructor. This method, which is now so universal and the value of which everyone recognizes, need not be dwelt on here. But I would accent the point, too often overlooked, that the dissection of dead material is primarily for anatomic purposes, and, in so far as it elucidates function, the latter must be read into the material by the pupil, either through the textbook or through the words of the teacher. In so far as this idea of function is omitted, the most valuable part of the lesson in dissection is lost. There is constant danger that, because of its comparative ease, the method of dissection of dead material shall be made the too exclusive means of physiologic instruction. Of far higher value for purely physiologic purposes is the method of vivisection. But, indispensable as this is in higher instruction and research, its employment with junior pupils is inadvisable. Yet, happily, nature has ordained that death of the body and death of the tissues do not take place simultaneously, and the teacher may make use of this fact to great advantage. A large range of physiologic facts may be demonstrated by the use of the surviving organs and tissues of the invertebrates and the cold-blooded vertebrates. I have found a turtle's heart to beat for three weeks after the death of the animal. The possibilities in the use of the frog's heart are well known; so also the frog's voluntary muscles, the frog's spinal cord, ciliary action in the frog's esophagus and in the gills of the clam; and a host of other illustrations might be mentioned. But in our zeal to teach physiology practically we must not fall into the error of thinking that only by cutting up things can this be done. For this method will after all give us only a partial view of a science whose domains are as broad as those of life itself, and, moreover, there is danger that it may develop in the minds of the more sensitive pupils a repugnance to a subject which ought not to be repugnant. Of inestimable value is the too often forgotten method of studying the living, uninjured being, either man himself or a lower organism. How much can be learned in this way in the study of one's own body is well shown by Mr Peabody in his *Laboratory exercises*, and how much in the study of uninjured lower animals and plants by Dodge in his *Practical biology*, to both of which excellent books I have already referred. I have always found it most interesting to students and most instructive, to have always at hand in my laboratory, living in a natural state, animals and plants, either terrestrial or aquatic, or both, to serve as constant demonstrations of the physiology of organisms. Aquariums and vivariums should never be absent from a place where physiology is taught. Furthermore, the use of models is to be encouraged, both the excellent anatomic models of organs which are now so readily obtainable, and specially the numerous models which can readily be made by the teacher or the pupil for the illustration of a considerable variety of organic functions. Thus, with all the possibilities before him in the use of uninjured organisms, the surviving parts of organisms, dead organisms, and anatomic or working models, and with the numerous books now in existence which give directions for the realization of these possibilities, the teacher of physiology at the present day has little excuse for not illustrating his subject in a way both instructive and attractive. It is my hope that at some future day we may be able to offer at Columbia a special course of instruction on the methods of teaching physiology.

I have referred to the repugnance which the more sensitive pupils, particularly girls, often feel toward the exhibition of anatomic material, of dissected animals or organs, and even toward the thought of picturing the processes taking place within their own bodies. Not even the teachers are free from this aversion. This feeling manifests itself in various forms. Sometimes it is merely the fancy that dead things are unclean. Sometimes it is a causeless shrinking from what has once lived and is now dead, the unreasoning shrinking from a corpse, and this shrinking may amount to an actual physical impossibility to handle or even closely to observe dissected parts. Sometimes it is an impression that a knowledge of one's own bodily processes is gross, improper, and immodest knowledge. My colleague, Dr Curtis, has suggested with no little degree of probability that this last phase of the mental phenomenon in question is the remnant of the old religious feeling of the middle ages, that the body is altogether vile in comparison with the soul, and that it should be scourged and debased and crucified. May the 20th century see the final casting out from the human mind of this remnant of a doctrine so unworthy of it! However manifested, this feeling is often real and deep-seated, and every teacher recognizes it as a serious obstacle in his work. It appears specially serious when we realize that often it is developed early in the child's mind by ill directed, or by the lack of well directed, home training. How much easier the work of the teacher would be if all parents were exterminated! Whatever its origin and however unfortunate it may be, the feeling of which I speak must not be either rudely ridiculed or grossly crushed. In the great majority of cases it can be alleviated, if not entirely cured, but experience has shown that there is no universal means of alleviation or cure. One enthusiastic teacher has told me of successfully combating a particularly aggravated case of this kind and thoroughly arousing the pupil's interest by making her realize that she was studying "the story of herself". She seemed never to have realized that she herself could have a story. The awakening of the girl's vanity was perhaps in this instance pardonable. But, notwithstanding the success of this teacher's effort, I can not but believe that in most cases the feeling of aversion would be less prominent if the opposite course were pursued, if the broad view of the scope of physiology were taken, which I have accented. Do not allow the pupil to get the idea, or if preformed, combat it, that physiology is "all about your bones and stomach and liver and heart". Make the study something more than a brooding over what goes on in the inside of the pupil's body, make it include the outside and all that the human body does. Make it comparative, make it a study of the living process, wherever and however manifested. The thought of physiology ought to convey with it thoughts of the beauties of life rather than repulsive pictures of death and mutilation. In dealing with this feeling the personal contact of the teacher with the pupil is of all importance, and each case should be dealt with as its own peculiarities suggest.

A word now as to the nature of the school course in physiology as modified by the age and previous preparation of the pupil. The idea is widely held that, since physiology is in substance the physics and chemistry of living matter, it should be preceded in the school course by physics and chemistry proper, and thus be relegated to a late position in the pupil's career. Some extremists would even remove it altogether from the secondary schools and confine it to the colleges. With this extreme position I can not agree; but within the high school or academy the scientific courses should be so arranged that physiology follows physics and chemistry. It should there be taught primarily as a pure science, but with its hygienic applications not neglected. Taught in this way and with abundant laboratory work, it would constitute, I believe, the very best and broadest discipline that the natural sciences are capable of giving the high school student. But the physico-chemical nature of the subject-matter of physiology need not, it seems to me, inevitably relegate the science to the latter part of the school course and to the older pupils. In fact, our wise legislators at Albany have decreed that the minds of the youth of New York are quite capable of appreciating the science at a very early period; hence in the public schools of the state its study is begun at an early age. Here is the critical period; the future of the science in the mind of the individual pupil is decided by the nature of the instruction that he receives at this time. If it be broad, general and biologic, the chances are great that he will be attracted; if it be made, as is too often the case, narrow, special and anthropocentric—and, I might add, alchoholic—the chances are that he will be repelled. A broad, general and biologic conception, in which the physiology of organisms—nature study, if you will—plays a prominent part, is quite in harmony with the introduction of hygiene, and the latter should in my opinion be made relatively prominent in this junior instruction. But beware of forcing the child into the state of a little friend of mine, who very wearily told me that, "Physiology is just 'don't drink, don't smoke, don't drink, don't smoke' ".

Now a few words regarding the problem of alchohol—not because there is any innate relation between alcohol and physiology, but because our lawmakers, the country over, have declared that a relation between the two shall exist in the schools. I recognize to the full extent the tremendous evils of the drink habit. I realize how serious is the problem of its control; and I would welcome any method that would successfully combat that habit. But, when I meet among the teachers the widespread feeling that the law regarding the so-called temperance instruction is a mistake, and their great disinclination to uphold the law literally, and when I hear the children right and left ridiculing the lurid lessons that are reiterated year after year by the textbooks regarding the evil effects of alchoholic drinks, I can not help feeling that the fanatics who have brought about such a state of things are doing a serious harm to the cause of real temperance among American youth. Pope had a correct understanding of human nature when he wrote:

> Vice is a monster of so frightful mien,
> As, to be hated, needs but to be seen;
> Yet seen too oft, familiar with her face,
> We first endure, then pity, then embrace.

The cause of righteousness was never promoted by misrepresentation or by making virtue nauseating. If the textbooks would tell the plain truth about the alcohol problem, there would be less cause for complaint, but it is notorious that they do not do so. And the belief is widespread and apparently well founded that a book containing the plain truth would have little if any chance of adoption by the school boards. Such a state of affairs is most lamentable; and I trust that the teachers themselves will not hesitate to speak their minds freely and endeavor in the interests of truth and genuine temperance to bring about a reform of the existing intemperate law.

But what now is the plain truth about the alcohol problem? I shall not attempt in this brief paper to review the whole subject, but the leading question is this: Is alcohol a food? In the summer of 1898 I had the privilege of taking part in the deliberations of the fourth International physiological congress in Cambridge (Eng.). The meetings brought together in the fascinating old university town a large and representative body of the world's physiologists, from the various European countries and Great Britain, from Asia, from Japan, and from America. The following statement prepared by Prof. Michael Foster, the most prominent of the British physiologists, was subscribed to by a considerable proportion of the members of the congress. It is stated by Prof. Atwater, who received these signatures, that "nearly all are well-known investigators. Among them are professors, teachers, and heads of laboratories of a large number of the most noted universities and medical schools of the world. The list includes many of the most celebrated physiologists of our time". The statement is as follows:

> The physiological effects of alcohol, taken in a diluted form, in small doses, as indicated by the popular phrase, "moderate use of alcohol," in spite of the continued study of past years, have not as yet been clearly and completely made out. Very much remains to be done, but thus far the results of careful experiments show that alcohol, so taken, is oxidized within the body, and so supplies energy like common articles of food, and that it is physiologically incorrect to designate it as a poison, that is, a substance which can only do harm and never good to the body. Briefly, none of the exact results hitherto gained can be appealed to as contradicting, from a purely physiological point of view, the conclusion which some persons have drawn from their daily common experience that alcohol so used may be beneficial to their health.

The value of this simple, quiet statement by men who are familiar with the trend of scientific progress and are directing the physiologic investigations of the world, men for whom truth is the constant goal of endeavor, can not fail to be recognized. The statement, it will be observed, is not simply a statement of opinion, but a summary of "the results of careful experiments." Since this statement was formulated, an American physiologic chemist, Prof. Atwater, of Wesleyan university, has conducted some of the most careful experimental researches that have yet been performed and has arrived at results which demonstrate, even more clearly than had been done before, the truth of Sir Michael Foster's words. Doubtless you are acquainted with the method of experimenting followed by Prof. Atwater. For his purpose the human body is a machine for the transformation of the energy of its food into heat and mechanical work, and it is comparable to a non-living machine, say a steam engine. Whatever energy goes out from the steam engine in the form of heat and work can readily be computed, and is equivalent to the energy that comes into the engine in the coal. The latter can also readily be computed, since it is nothing but the heat liberated in the complete combustion of the coal. So too with the living human engine, whatever goes out in the form of heat and work can readily be measured, and is found to be practically equivalent to the energy liberated as heat when the man's food is completely burned. The subject of Prof. Atwater's experiment, an adult man, is locked into an air-tight chamber, which is provided with walls of metal and glass, and is large enough to enable him to stand, sit, and lie at full length. The chamber is provided with ingoing and outgoing pipes for the passage of air, with doors for the introduction of food, with a bed, a table and a chair, with a stationary bicycle for doing work, and with a telephone for communicating with the outside world. Here the man lives for days, carefully watched by the scientific attendants. The most exact determinations are made of the chemical composition of the food and of the excreta, and of the amounts of energy taken in and given out. The effects of different kinds of food have been studied, and alcohol has been given a rigid test. In the alcohol experiments a known quantity of pure ethyl alcohol or whiskey or brandy is administered in place of a portion of the sugar, starch and fat of the food which contains an equivalent amount of potential energy. Prof. Atwater states his results briefly as follows:

> First, extremely little of the alcohol was given off from the body unconsumed; indeed, it was oxidized, i. e. burned, as completely as bread, meat, or any other food. Second, in the oxidation, all of the potential energy of the alcohol was transformed into heat or muscular power. In other words, the body transformed the energy of the alcohol as it did that of sugar, starch, and other ordinary food materials. Third, taking the experiments together, the body held its own just as well with the rations consisting partly of alcohol as it did with the others. . . In other words . . . the alcohol protected the nitrogen and carbon, the proteids and fats of the body from consumption as effectively as the carbonaceous nutrients which it replaced.

In view of these very careful experiments and their exact results, it seems to me that only an affirmative answer can be given to the question, "Is alcohol a food?" But Prof. Atwater finds that it is a food in small quantities only and in the sense of yielding energy to the body, but not of building tissue.

In yielding energy to the body it resembles sugar, starch and fat, though just how and to what extent it resembles them experimental inquiry has not yet told us. It differs from them in that it does not require digestion, and is hence believed to be more easily and immediately available to the body. It is not stored in the body for future use, like the nutrients of ordinary food materials. The quantity that may be advantageously used is small. If large amounts are taken, its influence upon the nerves and brain are such as to counteract its nutritive effect, and it becomes injurious in various ways.

(Whoever is specially interested in Prof. Atwater's work will find résumés by himself in the *Educational review* for June 1900, and in *Harper's magazine* for October and November of the same year.)

There are few things on this earth that are altogether vile. The world owes many blessings to the saving graces of alcohol; and I can not bring myself to believe that the fact that the Creator of all things has made the human body capable of obtaining energy from this much reviled chemical compound, will prove a serious obstacle to the propagation of a genuine temperance.

I can not draw my paper to a close without referring, very briefly to a general matter which interests all teachers of physiology in whatever academic grade—that is, the value of a training in our science as a general factor in education. The value of scientific training in general is so universally admitted that it is not necessary to analyze or demonstrate this, but the value of a special training in physiology is rarely recognized as it should be. In the classification of the natural sciences the physical sciences are often set apart, as exact sciences or sciences of precision, from the biologic sciences, which are termed descriptive; and the mental training afforded by the components of the one group is different in kind from that afforded by the components of the other. Physiology is unique in being at the same time in its subject-matter, its methods and its achievements both physical and biologic; a competent physiologist must be at once a physicist and a biologist; and, in harmony with the composite character of the science, training in it combines the educational value of the exact with that of the descriptive sciences. If the scientific education of the boy or girl is to be limited to one science, by all means let it be physiology, but let the instruction be characterized by broad-mindedness, generosity and sympathy. Huxley has admirably said:

> Leave out the physiological sciences from your curriculum, and you launch the student into the world, undisciplined in that science whose subject-matter would best develop his powers of observation; ignorant of facts of the deepest importance for his own and others' welfare; blind to the richest sources of beauty in God's creation; and unprovided with that belief in a living law, and an order manifesting itself in and through endless change and variety, which might serve to check and moderate that phase of despair through which, if he take an earnest interest in social problems, he will assuredly sooner or later pass.

In these closing days of the old century and opening days of the new, when a spirit of pessimistic discontent is widespread, and the "phase of despair" of which Huxley speaks is all too prevalent, the teacher has a great task to perform. To combat the prevalent tendency, to inculcate an inspiring and helpful optimism, to lead on to courage, high ideals and right living—this is what the study of life, properly directed, will do.

**Prof. James H. Stoller**—I regret that the time now remaining for the discussion of Prof. Lee's paper, which has given us so much pleasure, is very short. Might I ask Prof. Beal how long his paper is?

**Prof. W. J. Beal**—As long as you wish, Prof. Stoller.

**Prof. Stoller**—I suggest then, that we appropriate a few minutes from the general session indicated on the program for 4.30. That will give Prof. Beal time to read his paper in full, and the time left over we will divide equally for the discussion of the two papers. We may have about 10 minutes for the discussion of Prof. Lee's paper.

**Dr Charles Forbes**—I think we teachers of Rochester greatly appreciate the opportunities this convention affords for valuable advice and instruction. I have been a teacher for many more years than most of those who are present, and I am thankful that my teaching of physiology has extended from the grammar school, the high school to a professorship in college. What I wish to say is based principally on my experience in teaching this subject. I have taught thousands of pupils in physiology, and have not found that repugnance to the subject mentioned in the paper. The methods suggested by the writer are most excellent. The statement that there is not sufficient distinction made between anatomy and physiology may be true in many cases, but our textbooks are quite definite in regard to this matter. I agree with the writer that our textbooks are overloaded with anatomy, containing more than the subject of physiology demands. This, I judge, is one reason why there is a dislike to the study. As regards the physiology of botany, or vegetable physiology, Prof. Gray made it clearly understood many years ago that, while this is closely related to animal physiology, the two are distinct sciences. The subject has been made so clear that teachers ought not to let their pupils get the impression that human physiology comprises all of physiology.

At a convention like this so many ideals are presented by experienced teachers, that, while they meet with our approval, yet we are apt to be discouraged because we feel that we are not up to these standards. I think we all agree that the time for teaching the various subjects in our schools is so limited, the students have to do so much work and the teachers become so nervous under the responsibility, that it is very difficult to carry out the suggestions presented. One teacher said to me, "I am almost discouraged. I feel that I can not do my work properly, because I can not carry out the suggestions". I replied, "You are doing the best you can, and the teachers are working faithfully".

I have been interested in regard to the time when physiology is to be taught. In our grammar schools it is very elementary, as it should be; and the children in Rochester are pretty well instructed. Now, when the subject is taken up in the high school, it should be from the scientific standpoint. In most of our high schools it is commenced at once at the beginning of the course. I do not think under the circumstances that this is the proper place. From my experience I should say that it ought to follow physics and chemistry; because, as has been stated, physiology is the study of functions, and these are physical and chemical in their nature, so that, if the student is to study from a scientific standpoint, it will be after the study of these subjects. In this way the time of the student is economized; and we have to economize in this age when there is so much to be learned.

In regard to the note on alcohol, I do not know that we agree on that subject or the statement made. Even if it has been proved that alcohol is a food, is it any better than the other hydrocarbons? Shall we substitute alcohol for what we know is not injurious? I have a boy and girls in my own family; and it is worth something to have the children know what are facts even if they are exaggerated in the opinion of some, and I am very glad to have my children come home and tell me what they know about this subject. I am a physician, and, looking at these things from the standpoint of a physician, I do not fear that our young people will be intentionally falsely taught. The teachers of Rochester are interested in this matter and are doing their work faithfully. The teaching of the effects of alcohol and narcotics has its place in the system of hygiene. It is hardly fair, because one experimenter has announced that alcohol is a food, because he believes that a portion may be oxidized in the body, to assert that our textbooks are abounding in false statements. Those of us who are older and have had more experience in observing the effects of alcohol will still maintain that it is a poison, to be avoided. For this reason we should be careful not to prejudice the teachers' efforts.

**Inspector A. G. Clement**—I wish to express a word about the paper. I think it excellent, and I enjoyed it very much, indeed. It has been my privilege to visit, during the last year, perhaps as many as a hundred classes in physiology, and in different schools I have taken pains in a large number of cases to ask how they like the study. I found almost invariably that about one third or one half of the class dislike it, and I have attempted to find out why they dislike it, but have not always been able to get answers from the pupils. One or two reasons occur to me, however, as to why they dislike it. I think one reason is because the teachers are giving altogether too much instruction in structure and not enough in function. They certainly teach a great deal about bones and about the structure of various organs without showing the relation to function. Another reason is because too much instruction is given in regard to the effects of narcotics and stimulants. The pupils begin in the third or fourth grade and every year go over the same thing up to the 10th year. By this time the boys and girls think that the teaching of physiology and the teaching of the effects of narcotics and stimulants are nearly the same thing; and each year, as soon as the teacher begins to give that instruction again as required, they lose their interest and do not care to hear about it. Moreover, when the pupils have finished the work in physiology, if you ask them about the effect of tobacco on certain organs or the effect of alcohol on certain organs, you will find from their answers that they do not seem to know very much about it after all. I think it is unfortunate that some of our best physiologies have been thrown out of the schools because they are not approved by a certain very bright woman in this country. I know where a very excellent physiology was thrown out because it did not conform to her ideas. If teachers would give more practical instruction, as suggested in the paper, and more truthful instruction with reference to narcotics, the pupils would be more interested.

Another word with reference to the time of teaching physiology. I recognize the fact that it ought to be taught more scientifically, and it would be a very excellent thing if it could be; but the truth is, we are required to teach physiology in the first year, and before we can carry out scientific courses it will be necessary to add another course in the senior year of the high school. If that can be brought about, we can perhaps have physiology taught more scientifically than we now do.

## HOW SHALL A YOUNG PERSON STUDY BOTANY?

(A sequel to the *New botany* printed in 1879)

BY PROF. W. J. BEAL, MICHIGAN AGRICULTURAL COLLEGE

While studying four years in the classical course at the University of Michigan, and coming under the instruction of Alexander Winchell, I was seized with a desire for more knowledge of natural history. It was two years later, in April 1861, that I went to Harvard to study under the guidance of Agassiz and Gray. In those days the gross anatomy, morphology and the classification of animals and plants were about all that received much attention.

Agassiz said he was glad to see me there and asked a few questions, observing that, "You must make up your mind to be a poor man all your life if you become a naturalist. With my mode of treatment students are about sure to become discouraged at first. I shall try your patience. You have read books, but have not studied the subjects themselves. If you study with me, you must not look at a book for some time, for several months. You must learn to see, to observe for yourself. After students get started once in this way, the longer they study here the better they like it, and the more reluctant they are to leave." After some more questions, he handed me half a dozen dead sea-urchins, and left me with the remark: "I want you to see what you can make of them, and in a day or two I will see how you get along." He assigned me a table in the laboratory, where ten or a dozen other special students were at work, the floor being largely covered by cords of shallow wooden boxes set tightly over each other, containing various kinds of specimens. This was a queer way to study—six dry specimens about as large as so many

Baldwin apples and no books! I looked them over and over, part of the time using a small hand lens. I was glad when night came, for it seemed as though I had learned all there was to be learned of sea-urchins. I broke them to pieces and made some drawings. The next day the professor called with a smile, saying, "Well, Mr Beal, what have you seen?" He glanced at the drawings, and I told him what I had done. He gave me a very few general hints of what to look for, and a few names of the parts, noticing some mistakes, but made no corrections.

I supposed all of one day spent on these specimens certainly was enough. Not so; I was to study them longer. Thus he called every day for about five minutes during a period of three weeks, hearing what I had to say till I made some mistake, when he uniformly turned on his heel and left me, saying, "You are wrong." I was surprised at my own work—surprised to find at the end of the three weeks, that I was discovering something new every day. You must understand that, during this time, I had only two lectures a week on other subjects, devoting all the rest of the time to sea-urchins. After this I dissected specimens which had been in alcohol, and occasionally went to Chelsea beach to get fresh, living specimens, which I examined while in motion. I began to learn to see sea-urchins, and it made little difference to me whether it was daylight or dark, whether the specimens were before me or not; visions of sea-urchins in all their details were all the time before me.

In a similar manner one species of star fish was examined, its examination occupying a week or so. Agassiz says: "These two animals, the sea-urchin (a flattened sphere) and the starfish (with five rays or arms), are composed of similar parts arranged in a similar manner. Learn how it is." The comparison occupied several days. The next specimen was a spatangoid, an animal somewhat different from either of the others. "Now homologize these three." Then a third and a fourth specimen were given me, differing from the others in appearance; and I was told again: "Compare. It is easy to observe isolated parts—any one can soon learn to do that; but, when you compare two objects, you take a step in philosophy." In one case I was asked to make a paper model of a coral, to illustrate my idea of the hard portions. Corals were compared with sea-urchins and starfishes. This work occupied me for more than two months, and during all this time Agassiz never corrected a mistake, but kept me working till I found out for myself. Perhaps it was three months before I was permitted to see books on these subjects, but at that time their contents were carefully read and fully understood. Agassiz often said: "Study specimens and refer to books, and not the reverse, as is usually done. Textbook knowledge about nature does not amount to anything; it is a very poor basis of culture."

It has seemed to me that the work with Agassiz helped me more than that of any other teacher with whom I ever came in contact, and yet no teacher ever told me so little. I learned to observe and learned to rely on myself. At that time we supposed that this kind of work was beginning the study of zoology in the right way, but in these days, some people are trying to make a new thing out of it, by calling it nature study. Nature study is seeing the things which one looks at, and the drawing of proper conclusions from what is seen. In this connection it may be well to keep in mind Dr Goodale's definition of botany. "Botany attempts to answer all reasonable questions about plants."

I spent months studying asters, goldenrods, sedges and other plants in the laboratory with Dr Asa Gray, who was always on the alert to keep me on the right track and point out the mistakes at once, saying, "It isn't worth while to pursue a subject when you have got off the right track."

For at least half a school year of daily work in beginning botany, I require all students to pursue the plan of studying plants and not books. By all devices, I seek to get the results of the combined observations of all members of the class before I tell them what I think, or before they study books on the topic. It makes no difference what grade of a high school or what class in a college they belong to, the process is the same. With young pupils and undergradutes, I do not carry out Agassiz's plan to the full extent, but keep it constantly in mind, tempering the severity of the breeze to the shorn lambs.

After the students have learned well how to see for themselves by practising for 18 or 20 weeks, in succeeding terms, I am by no means so particular to adhere to this plan.

In many of our elementary textbooks in these times—and they are numerous and multiplying rapidly—authors recommend the study of what they call types. For example, they advise studying one spirogyra, one vaucheria, one mucor, one puccinia, one ascomycete, one marchantia, one polytrichum, and so on through, from low protococcus to one of the highest—the dandelion. In pursuing this plan, my experience convinces me that most students fail to see the connection and lose interest in passing from one isolated family or class to another. It may be well enough to study types, but pupils should not fail to study in that connection a considerable number of species that are somewhat nearly related, and by this means have the benefit of comparing similar objects. After learning the structure of one violet, it is better to examine the structure of at least 10 other species than to spend the same time studying a single crowfoot, a chickweed, a geranium, a spiraea, a rose, a mint, a phlox, a mallow, a dandelion, a fern; though each of these may be studied at other times in connection with allied forms.

25 years ago, we often met teachers in Michigan who required their pupils to begin botany by getting lessons from a textbook, where they saw some pictures and diagrams, instead of plants or some of their parts. This was the practice, specially in winter, when it was declared no specimens were to be obtained. I am sorry to say that such persons in the back districts are still retained as teachers. Perhaps I ought not to mention this matter in New York; but it is not three years since I met one of your teachers, occupying a high place, who followed the book lesson plan, with little or no use of specimens. Is it possible that he was unable to procure large seeds of some common plants and set his pupils to observing, experimenting with, and growing them in the classroom? Had he not collected many dry seeds, fruits, and racemes in summer and kept them in bunches or in loose sacks hung on the nails in the rafters of an attic till wanted in winter? The fact appears not to

have entered his head, that he could secure, each in its season, a great assortment in quantity of the soft fruits and buds of flowers—that he could keep these in jars in 2% of formalin 'till wanted. They will retain their shape and part of their color very well, and the odor of formalin disappears after washing in water for a few minutes. True, we can not collect roses from a New York garden in January, nor maple blossoms in February, but our trees and shrubs in their winter garb furnish excellent lessons to employ pupils profitably for many weeks of winter, and this all comes within the scope of botany, just as much as if we examined flowers in May or June. By the roadside, in the swamp, in the woods or the front yard, are hundreds of branches of a hundred kinds of woody plants, the buds of which are formed in summer and resting in winter, some of them waiting to be studied by inquisitive pupils. The branches have pith, wood and bark, to say nothing of the delicate contents of buds. Students can pursue the following order with branches of our elms and find plenty to do.

1 Note general characteristics of branches, including the arrangement of buds and the abortive stem above the upper bud.
2 Lenticels, corky ridges, and the bark.
3 Leaf scars, their position, shape, structure.
4 Scars left by the bud scales, and minute buds in their axils.
5 Scars left by some of the dying buds.
6 The buds { 1) those containing a stem and leaves,
  2) those containing flowers.

The longer I teach, the less I lecture my students, and the talks that are given are mostly regarding things which the students have previously examined. As a rule, I have to keep cautioning our instructors not to lecture so much. I have had some who apparently delighted to show their wisdom and would spend more than half the laboratory hour in telling students what they should attempt to discover for themselves or in giving other information. Students are inclined to like this plan, as it is so much easier and quicker to get information this way than to work it out for themselves. They do not reflect that they are pursuing the study to learn how to work rather than to acquire information.

In 1869 I gave members of the junior class in Chicago university some lectures on zoology; I was particular to tell them about the structure of the heart, and the circulation of the blood. Two of the class afterward dissected a dog that was good for nothing else. They wondered what those broad things were at the large end of the heart, and were going to cut them off and throw them away, not mistrusting that these were the auricles about which I had told them the day before. In 1885 I gave to an advanced class five illustrated lectures on the pollination of flowers. After the course, I asked questions and made the following record in my notebook. "As far as the lectures are concerned, many points were imperfectly understood, erroneous notions were entertained. The five lectures were to a great extent a loss of time, which could have been spent to better advantage by a careful study of the flowers of several living species."

Better than lectures I have found the following, not omitting laboratory work. I teach agricultural students something concerning grasses, weeds, parasitic fungi, forestry, plant physiology. After they have done some laboratory work, students are supplied with duplicate books, bulletins, or separates, which treat specially of the subject in hand. These are read by each one during the laboratory hours, and the students take their time for making good notes. These books and bulletins are a part of the laboratory equipment. For example, beginners study seeds and seedlings of peas and beans for four hours, making some notes and drawings, after which I give each a copy of my bulletin, no. 1, on elementary science, which treats of the same kinds of seeds and seedlings. Copies of this bulletin are on the table at this meeting. Wheat and buckwheat are studied in the same manner, and later seeds and seedlings of timothy and clover, each time finishing up with a bulletin. I can conceive no more desirable method than to have the whole series of topics which are studied during a term, written up and illustrated in this manner, that the text and cuts may not be seen till considerable attention has been given to the objects. In case a book is furnished to a beginner, while he has specimens, he is almost certain to use it as freely as a student would use the translation of a German or Latin text which he is trying to translate.

In Michigan, many persons preparing for examinations with a view to securing certificates, cram in botany and zoology, physics and chemistry, instead of making original observations or of making the experiments for themselves. Not long ago our state superintendent of public instruction introduced a fine scheme for a part of his examinations in botany. Those who were trying for state certificates, were given some questions to be answered in writing on the usual plan, while another part of the examination consisted in using a stage misroscope with paper and pencil and no books to give the result of their observations concerning some fresh plants placed in their hands. Such questions are most admirable, and are fair, but in this case most of them were unanswered, showing that the candidates were destitute of the most important part of the preparation. Some of them failed to make a passing record. In examining candidates to enter an advanced class, I invariably make considerable use of laboratory work and less of oral quizzes.

Students should keep the following four points constantly before them to aid in arriving at correct conclusions.

1 Where possible, examine many specimens of one species.

2 Pay considerable attention to counting and measuring and finding the relative sizes of the parts studied.

3 Carefully compare homologous parts of allied species.

4 Study plants of any species in all stages of development.

As we must expect, beginners are often at a loss to know how to express themselves clearly and fully, specially in writing descriptions of plants or parts of plants that they have never seen before. Their notes are very often too meager. After all have tried and done the best they can, I show them what I can do, or permit them to copy an apt description from some book or from a blackboard. After repeating this process for several times, they soon begin to acquire considerable skill in description.

I like to keep a syllabus of the course on the blackboard or to have it on a chart hung before the class.

Many textbooks contain in the introduction or in some of the early chapters a lengthy account of the classification of the subjects treated in later chapters. Here they attempt to teach classification before the beginner has acquired a knowledge of facts as a basis sufficient to comprehend the text. I wish to call your attention to a notable exception to this rule in a *First book of zoology* by E. S. Morse, published more than 25 years ago, before some of you were born. The plan is admirable. The author speaks to his pupils by text, and excellent illustrations of snails, clams, insects, centipedes and lobsters, and in the last part of the book, where you would least expect to find it, he inserts a few chapters concerning natural groups. Here we have the natural order of work; a multitude of facts are given before the author attempts to generalize or classify.

What I term beginning botany, is expected to continue daily for 18 or 20 weeks, devoting an hour and a half a day to the laboratory, with sections containing each 25 to 30 persons. Each student is furnished with a stage microscope, with two needles in handles, a pair of forceps and usually a small knife. During this period the teacher must see:

1) That he learns to use these instruments to best advantage, correctly. 2) That he learns to draw diagrams, vertical and cross-sections, rather than artistic views. 3) To make good and full notes. 4) To learn something about plants.

In certain cases, I find it very instructive to require students to make models out of paper or out of large rutabagas or potatoes.

Certainly in no course should a student attempt to study everything pertaining to botany. We must select with reference to that which is most suitable for students that we teach and the apparatus that is available. We select what will give the best training, and lastly that which will give the most useful information. If all were intending to pursue the study of medicine, or of mechanical engineering or of agriculture, or of horticulture, the fact might influence more or less the topics to be selected, but the pupils in most schools will pursue a great variety of callings after completing a course, or before that time. We must keep in mind all the time that " what a man can do is more important than what he knows."

For acquiring the power of daily observation, there can be nothing better than the study of the gross anatomy of plants, and for cultivating the judgment, plant morphology is unsurpassed, specially where frequent comparisons are insisted on. While these two lines of work are kept at the front, from the first lesson on the first day and all through the course, I encourage every student not to forget to ask himself the question, " Why and how? " This will call in more or less physiology, oecology, description and classification or relationship. Under oecology specially these questions are always interesting: why plants are not all found in the same region, why they do not all flower at once. Here come in the modes of plant dispersal, the struggle for existence and more room, zonal distribution, plant communities, adaptation to climate, how plants protect themselves.

Fortunate, thrice fortunate is the botanical teacher who can draw diagrams well and with some alacrity, for it helps amazingly in making explanations. It will save many tedious repetitions in the explanations, if a short syllabus or specific statement be produced in duplicate, so that each student can have a copy. There will always be some in a class who were not giving close attention when something was said, or some member will be absent.

No person for the first 20 weeks of botany should be at the trouble of learning to use a compound microscope. He should leave it, till he has made a somewhat intimate acquaintance with the gross anatomy of plants.

There are a dozen or so designs or blank forms published, having spaces opposite printed names, in which to answer direct questions about a plant in flower. It is well enough to place about three copies of this in the hands of each student as he examines three different plants, but to continue their use for a greater length of time will tend to relieve the student of thinking and make a machine of him. The quicker he learns to ask his own questions and answer them the better, even at the risk of some omissions.

It seems to be necessary to spend some time in the classroom, to aid pupils in becoming familiar with artificial keys which lead to families, where a plant in hand may be described and named, but, with the other instruction provided for, but little time need be given to this work. This work is too often spoken of as analyzing plants, instead of identifying plants. I place a very low estimate on a common practice of requiring each person in a class to collect, dry and mount 50 to 100 plants.

I have not had much experience in conducting field excursions, because my teaching has been done at a college which has a large campus containing a great assortment of trees and shrubs, and because there is at hand a botanic garden where the plants are arranged in families, each plant growing back of a label which contains its name. It is a part of our plan in the spring term to go once a week, with the students in small companies of about a dozen, where some interesting features can be pointed out.

A botanic club or a natural history society in a school is well worth encouraging. Let it be officered by the students, and help them to get up programs, remembering that no society of this kind can long maintain an interest among its members, if they plan to have little else than a lecture at each meeting. The members should be the actors on the program.

I inclose a copy of a reprint from the first report of the Michigan academy of science, entitled:

## SUITABLE TOPICS FOR DISCUSSION BY YOUNG MEMBERS OF A BOTANICAL CLUB

BY W. J. BEAL, AGRICULTURAL COLLEGE

(Read before the Academy, April 1, 1897)

In some respects the botany taught in our agricultural college should be unlike that introduced into a portion of the courses in a university. For example, the young person bent on agriculture or horticulture in any of their departments would not need to spend time in the study of mosses, liverworts, lichens, or algae, or many of the saprophytic fungi. On the contrary, he does need to learn the names and many of the peculiarities of our native and introduced trees and shrubs, the same of the leading grasses, clovers and other forage crops; he needs a familiarity with our weeds, including the seeds of cereals and other field crops, our parasitic fungi, especially those injurious to cultivated crops and weeds of all kinds, and some knowledge of the anatomy and physiology of the higher plants. In a word, he seems to have a greater need of the old-fashioned systematic botany than is generally expected in these times in the courses of a university.

Especially should the agricultural student from the start take much pains to become a close and accurate observer of plants in the field, orchard, and garden, in fact anywhere found.

For such a course the electives need not be numerous.

For many years past at the state agricultural college there has been a natural history society with meetings once a month, at which the observations reported referred mainly to agriculture, horticulture, botany, zoology, and entomology.

A little over six years ago, a botanical club was established with meetings in the botanical laboratory three or four times a month. The attendance averages from 10 to 20, with a membership of about 50.

During these six years of its existence, there have been presented 219 topics. Most of the members are mentally young. I have here a list of 75 or more of these topics, which seem to be models of their kind for such members to consider. As one of the objects of the State academy of science is to encourage young people—or older ones either—to pursue some lines of investigation appropriate to our aims, I thought this list of topics would be interesting to such young workers or members of a young natural history society. It may be needless to say that in nearly every instance the paper or talk gave the results of personal observation.

A comparison of the fruits of our three elms.

The flora of Michigan, some notes on.

Beech drops.

The odor of plants.
The box elder.
Proper work of a botanical club.
Thistles of the neighborhood.
A study of the leaves of arbor vitae.
Comparison of the buds of several oaks.
The fruit of the red mulberry.
Comparison of the twigs of three pines.
The roots of the red clover.
Pop corn, before and after popped.
The roots and leaves of a young wheat plant.
The report of a field day.
The flowers of campanula.
The flowers of the common sage.
Petiolar glands.
The life history of corn smut.
Notes on how to observe.
Notes on leaf galls.
The attractions of the botanic garden.
A talk on wheat.
Remarks on native goldenrods and asters
A comparison of beechnuts from several trees.
Large varieties of fruits of a hawthorn.
Autumn leaves.
How botany is taught at the state university.
Notes concerning Dr Watson of Harvard, recently deceased.
Detecting the adulteration of buckwheat flour.
A talk on some of our ferns.
A talk on the origin of cultivated plants.
Some of our fresh-water algae by an amateur.
A fungus growing from the neck of a larva.
The adulterations of tea.
Observations on the black knot of the plum.
The adulteration of coffee.
Fasciation in a dandelion.
Our erysiphae and their hosts illustrated.
Report of the meeting of the A. A. A. S.
Different forms of leaves on the same plant.
Carnations, structure, etc.—the models.
The "flow" of sap in the sugar maple.
Questions asked of the botanist of the experiment station.
Our willows—illustrated.
Some of our earliest grasses.
The structure of a puffball.
Plans of some experiments for preventing smut in oats and barley.

How to kill quack or couch grass—why?

Botany as seen in the German exhibit at Chicago.

Some of the curious plants grown in the greenhouse.

Four persons talked of as many different kinds of smuts.

Our native orchids.

Two kinds of wild potatoes grown in the botanic garden.

Some of the fungi grown on tomatoes.

The cross-fertilization of wheat.

The improvement of our wild fruits.

Some monstrosities among plants and their meaning.

History and development of some of our grapes.

The mode of distribution of some seeds.

Observations on Michigan pines.

The irregularity in the germination of seeds of weeds and the advantage to these plants.

Sub-irrigation in the forcing house.

An exhibit of seedling willows.

Observations on oak galls.

A comparison of plants of wheat and chess.

An exhibit of tomatoes grafted on potatoes, both bearing crops—double cropping.

Experiments with smut on wheat.

Concerning the State academy of science which met at Ann Arbor June '94.

A visit to Greenland by one of the founders of the club, Mr Orth.

An exhibit of fruits of our native trees and shrubs.

A plant of wild strawberry in the botanic garden had produced by runners 1234 plants in one year.

The structure and use of bulliform cells in the leaves of some grasses.

The structure of root tips of wheat, and some branching hairs.

Squirrels dropping cones from trees and biting off limbs.

Exhibition and description of an artificial cell to show turgescence.

Report regarding the abundance of variegated corn in the field.

The life history of Monilia—plum rot.

An exhibit of chess which had germinated on ice.

An account of cutting wild rice, rafting down the river and curing for hay in '95.

Report concerning a visit to the U. S. department of agriculture and the M. A. C. men there employed.

The management of the woodlands of the college farm.

The structure and history of the navel orange.

Fairy rings on our lawns (marasmius).

A meeting in the evening at the botanic garden to observe the opening of flowers of the evening primrose and to see insects at work on various flowers.

The crossing of pop corn and field corn.

Life history of rust on wheat and barberry.

The seeds of weeds.

I hardly need to add that any botanical club or natural history club will make slow progress and work to very great disadvantage unless one or more of the members possesses already a very good knowledge of one or more divisions of natural science. If possible, such members will be of more aid in securing interest than a library.

For many years, I have assigned each term one or more suitable topics, a different one to each member of the class, which he considers his personal property. These topics the pupil investigates thoroughly so far as he can, and each member in turn presents his paper, or talk, usually with illustrations, to the other members. The quality of the work like that of a recitation is credited as equivalent to two or three, or more good or poor recitations. I have uniformly found that students took an interest in this plan. For numerous suitable topics consult the *New botany*, noticed elsewhere.

Frequently an opportunity arrives for advertising the members of a class a little. I consider the time well spent, provided the preparation is all of it in line with the legitimate work of the class during that term. Some of the teachers may be interested in a plan which I tried in 1886. In Michigan we have a thrifty state horticultural society that holds meetings in different parts of the state, thus performing missionary service. A meeting was to be held near the college with which I am connected. College was in session. I thought to stimulate the students of a certain class and interest the members of the society. 17 young persons gave three minute talks to the horticulturists on topics which they had been studying by the aid of the compound microscope. The subjects of the talks given were as follows: 1) structure of a leaf; 2) the mouths of a leaf; 3) young hairs of a leaf; 4) sting of a nettle; 5) talking and showing drawings of protoplasm in motion; 6) palisade cells in a leaf; 7) starch of common and wild potato from Arizona compared; 8) the framework of a leaf; 9) fibers of cotton, flax and wool compared; 10) why nuts are hard; 11) tough and brittle white ash compared, as seen magnified; 12) structure of a grain of wheat; 13) pollen and its growth; 14) quince rust; 15) corn smut; 16) a study of common bread mold; 17) effect of severe cold or heat on the cells and their contents.

The secretary reported: "The drawings were admirably executed, and on the whole the entire exercise was as interesting as anything ever presented to the society." The illustrations were copied and with the text appeared in the report of the society in 1886, which gratified the students and probably did them no harm. Some of you may find occasion where a short exercise illustrated and presented by a class, each saying a little, will attract much greater interest than where only one or a very few speak longer. And no doubt some of you may have already tried this plan.

Even for college students I have found it beneficial to write neatly on the blackboard some motto or sentiment which shall catch the eye for two or three days. Here are some that I have used. No real progress can be made in botany, till the student learns to observe. Neatness begets accuracy. "Mere book knowledge of natural history is a sham and a delusion." (Huxley) "The pupil must earn his facts." (Goodale) "The teacher of biology will keep the student on the right track, but let him find the truth himself." (Farlow) Make frequent and thorough comparisons of two or more plants or similar parts of plants. "In biology, laboratory work should precede any detailed course of lectures." (Farlow) Details and facts before principles and conclusions. To learn to observe well, concentrate the attention for some time on a very small portion of the field, then in like manner study other portions. As an instrument of research, the microscope now occupies a position which is second to none. A trained eye is valuable in any kind of business. Merely learning the name of a plant or part of a plant can no longer be palmed off as valuable training. Correct teaching of botany is simply giving the thirsty a chance to drink. He who expectorates on the floor must not expect to rate high in his class. To lose a lesson is to unsettle a week. "He who can teach only by the book had better not begin." (Prof. Wesley) "From first to last the student should be an investigator." (Prof. Wesley) "Patting one on the back and saying, 'Don't you see this?' and 'Don't you see that?' does not tend to produce a very robust mental development." (Farlow)

You should not neglect to tell the members of your board of control, whether they like to hear it or not, that giving good instruction in natural history is costly, but, notwithstanding the cost, no one in these times can lay claim to a liberal education who has not had a pretty good drill in botany or zoology or both of these. By costly, I mean not only to take into account the apparatus required, but the sizes of the sections and the hours for the work. For example, it costs about five times as much to teach a class of 30 in the subject of parasitic fungi as it does to teach the same students history or political economy.

None of us will ever live to perfect a course in botany that will stand the test of future discoveries and methods of teaching, nor shall we ever agree for a single year as to what should be taught or how it should be taught. In his report for 1888-89, Pres. Eliot said:

> During recent years every college teacher has been forced to answer anew the personal questions, What can I best teach, and how shall I teach it? Every man has really been obliged to take up new subjects and to treat them by new methods. There is not a single member of the faculty who is today teaching what he taught 15 years ago, as he taught it then. Each teacher has to recast his work . . . and the faculty has to invent, readjust, and expand the comprehensive framework of the course.

Altogether likely most of those present agree as to the great value of a training in botany. I venture to give my opinion:

1 There is nothing better for training the power of observation.

2 The comparison of one plant or one part of a plant with another cultivates the power of inductive reasoning.

3 In learning the definition of new words, the memory is strengthened, the vocabulary enlarged.

4 There is nothing better to train the power of precise and brief description in using each word with a definite meaning.

5 To follow successive changes that take place in shape, proportion, size, color, as seen in one plant from seed to maturity, develops the observation, powers of description, and the judgment.

6 By experimenting to learn the results that follow changes in temperature, light, moisture; by mutilating or removing certain parts, many facts may be obtained, enabling one to arrive at certain correct conclusions.

7 To become acquainted with the minute anatomy of plants by the aid of sections made in different directions and seen with a compound microscope, cultivates the imagination as well as the powers of observation and reasoning.

8 The preparation of materials for examination trains the hand to precision as well as the eye and the judgment.

9 "In studying botany a student gains in analytic and synthetic powers." (T. C. Abbot)

10 "It is the best system of practical logic, and the study exercises and shapes at once both the powers of reasoning and observation more probably than any other pursuit." (Asa Gray, who possessed a good knowledge of mathematics and Latin as well as of botany)

What shall I say of the value of training acquired by studying bacteria and lichens, by experimenting to demonstrate that certain fungi, like wheat rust and many others, assume two distinct forms on each of two different host plants?

In these times textbooks for beginners are appearing in rapid succession. It is a barren month in which one or more are not published. In two instances within my knowledge, the editor has prepared two books for young students, and in one case three books by one author have appeared within a period of two years. New textbooks are always welcome to teachers, but the difficulty of selecting just the right one is not so easy. What does this influx of botanical textbooks mean? Simply this, there are many persons interested in botany, and the subject is undergoing rapid changes. New discoveries in new channels make it an inducement for teachers to try a hand in making a new book. At present, the subject is in a somewhat chaotic condition. I have shown myself lacking in decision of character, by inability to select a textbook for beginners that just suited me. I have tried several. to discard at last all of them; and finally, to put into the hands of competent instructors—and no others should attempt to teach—I made a small work myself. Of course you have not seen it, for it is not in the list of any publisher. In the preface I wrote the following lines:

> I object to telling students at every step what they are to see, or to imply as much by numerous direct questions. I think it unwise to place in the hands of a beginner a book containing good pictures of what is to be learned from specimens. To give him a full text and good pictures is much like placing a translation in the hands of one who is studying Greek, Latin or German. Excepting as a model now and then, I do not think it best to supply printed schedules for plant study.

With those views in mind, all we need to put in the hands of a student is a brief outline of the course and a good glossary at the end of the pamphlet. Students are all supplied with good specimens in abundance at all times of the year; then what are pictures for except to tell the student what to look for? Having seen that, he believes he has seen all there is to be discovered. His curiosity ends then and there. Neither is it a good plan to lecture a class of young students implying that you are telling all there is known on a certain point—that there is nothing more to learn about the subject. Tell them rather, that no one knows it all, that here is a fine chance to make original investigations and you are about sure to be right in such statements.

As helps to teachers of botany, no one can afford to neglect to read the *Teaching botanist*, by W. F. Ganong, published in 1899 by Macmillan.

To my students, who are about to study with the aid of a compound microscope, I take great pleasure in reading parts of a most admirable paper by Dr W. G. Farlow on biologic teaching in colleges, printed in the *Popular science monthly*, March 1886. Some of you may like to secure a copy of the *New botany*—a lecture on the best method of teaching the science by W. J. Beal. Third edition. 1890. 10c. Published by the *Rural New Yorker*, 409 Pearl st. New York.

### PARTIAL LIST OF ELEMENTARY TEXTBOOKS ON BOTANY

**Atkinson, G. F.** Elementary botany. N. Y. 1898. Holt $1.25.

——— Lessons in botany. N. Y. 1900. Holt $1.

**Bailey, L. H.** Lessons with plants. N. Y. 1898. Macmillan $1.10.

——— First lessons with plants. N. Y. 1898. Macmillan 40c.

——— Botany: an elementary textbook for schools. N. Y. 1900. Macmillan $1.25.

**Barnes, C. R.** Plant life considered with special reference to form and function. N. Y. 1898. Holt $1.12.

——— Outlines of plant life, with special reference to form and function. N. Y. 1900. Holt $1.

**Bergen, J. Y.** Elements of botany. Bost. 1896. Ginn $1.20.

——— Foundations of Botany. Bost. 1901. Ginn.

**Bessey, C. E.** Essentials of botany. N. Y. 1896. Holt $1.08.

**Bower & Vines.** Course of practical instruction in botany. Lond. 1885. Macmillan.

**Campbell, D. H.** Elements of structural and systematic botany. Bost. 1891. Ginn $1.

**Clark, C. H.** Laboratory manual in practical botany. N. Y. 1898. American book co. 96c.

**Coulter, J. M.** Plant relations: a first book of botany. N. Y. 1899. Appleton $1.10.

——— Plant structures: a second book of botany. N. Y. 1899. Appleton $1.10.

**Darwin, F.** Elements of botany. Cambridge Eng. 1895. University press.

**Evans, E.** Botany for beginners. Lond. 1899. Macmillan.

**Gray, Asa.** Elements of botany. N. Y. 1887 and later editions. American book co. 94c.

——— How plants grow. N. Y. 1862 and later. American book co. 60c.

**Kellerman, W. A.** Elements of botany. Phila. 1883.

**Macbride, T. H.** Lessons in elementary botany. Bost. 1896. Allyn & Bacon.

**Macdougal, S. T.** The nature and work of plants. N. Y. Macmillan. 1900.

**Massee, G.** The plant world. Lond. 1898. Whittaker 2s 6d.

**Newell, Jane H.** Outlines of lessons in botany, pt 1 and 2. Bost. 1892. Ginn 90c.

**Rattan, V.** A popular California flora. San Francisco 1882. A. L. Bancroft & Co.

**Setchell, W. A.** Laboratory practice for beginners in botany. N. Y. 1898. Macmillan 90c.

**Spalding, V. M.** Guide to the study of common plants. Bost. 1895. Heath 90c.

**Willis, J. C.** Manual and dictionary of the flowering plants and ferns. Cambridge Eng. 1897. University press 10s 6d.

**Prof. James H. Stoller**—I would suggest that the discussion of Prof. Beal's paper, so interesting and so full of practical suggestions, may be had very well in connection with the paper to be read tomorrow morning, the "Framing of a course in biology for untrained minds". I suggest, with Prof. Beal's consent, that we defer the discussion till that time, and, if we come promptly together, we shall have time for the discussion of both papers.

## Section C. EARTH SCIENCE

### PRACTICAL EXERCISES IN PHYSICAL GEOGRAPHY

BY PROF. W. M. DAVIS, HARVARD UNIVERSITY

There is coming to be a general recognition that physical geography must not be taught by recitations alone; that laboratory and field work should be systematically developed for the better understanding of the principles and examples set forth in the text; and that a proper assignment of space in the school building and of time in the school curriculum should be made for the accomplishment of these practical exercises. There is a growing movement in favor of practical exercises; a movement whose strength is to be measured not by the number of teachers who are standing still, indifferent to this innovation on traditional methods, but by the number and character of the teachers who are striving, often against difficulties and discouragements, to promote the rational development of their subject. There was a time only 10 or 15 years ago when a " geographical laboratory ", as the name for a room specially set apart and equipped for practical exercises in geography, had no place in the school architect's plans; but, if one may judge from the amount of inquiry and correspondence as to what a geographic laboratory should be and as to what it should contain, such a time is passing by. Let me then devote this address to certain considerations regarding practical exercises in physical geography, in the hope that my suggestions may find some application in the construction of new school buildings, in the arrangement of new school courses, and in the appointment of new school teachers, as well as in the remodeling of old ones.

First, as to the place in which practical exercises are to be carried on. An ordinary schoolroom, fitted with desks of the usual size, one for every pupil, is unsatisfactory in not affording proper accommodation for the maps and models which the pupils are to study, describe, or copy. Broad tables near good-sized windows, and movable or suspended racks are well nigh indispensable. Hence the importance of having a room specially set apart for work of this kind, a laboratory in which dust-proof racks, cases, and closets give convenient storage for materials not in use, a laboratory adjoining the classroom in which recitations and lectures on geography are given. The laboratory need not be so large as to contain table space for an entire class, for the class may to advantage do much laboratory work in small sections—indeed, if no special laboratory is provided, the enterprising teacher will do all he can on ordinary desks; but it is a pity to hamper good work by unfavorable conditions. A combination of classroom and laboratory is practicable in schools of moderate size; but in large schools, a geographic laboratory is as important as a physical laboratory, and in the modern school buildings, where so much consideration is given to every need of the teacher, the geographic laboratory is, we are glad to say, coming to be included in the architect's plans.

The practical teaching of geography needs furthermore a flat space on the roof for observation of the sky, a basement room where experimental illustrations of land and water may be made without danger of injuring the ceiling of a room below, and a reservation in the schoolyard where a meridian line may be marked and various outdoor exercises may be carried on. It needs also a field for outdoor work, and this is, fortunately, always at hand without expense to the school committee: it is curious to note how generally the school teachers' needs are now served by electric railways, which so greatly reduce the difficulty of transportation.

Let us next consider the subdivision of practical exercises as to kind. The classification adopted should follow that of the textbook in use in the school: in general it will contain four chief groups, the earth as a globe, the atmosphere, the oceans, and the lands. To these four, some would add human conditions as a fifth; but my preference is to distribute this subject over all the others, so that it shall never be separated from them in the minds of the pupils. Latitude would then be taught, not as an abstract mathematical problem, but as an ingenious and practical device which man uses in order to indicate his place with respect to poles and equator. The sea bottom would then be described not merely as a dark, cold, quiet, monotonous plain, but as a contrast to the light and dark, cold and warm, quiet and active, ever changing surface of the land on which is found that variety which even poets recognize as the very spice of life, and which biologists recognize as the inspiring cause of all its higher growths, culminating in the development of man himself. It is, however, not necessary to give more space here to determine whether the classification shall be fourfold or fivefold, but it is worth while to point out that the exercises devoted to the several groups differ very widely in character. The earth as a globe must be dealt with geometrically; if formal geometry has not been studied by the class in physical geometry, let the work proceed by inspectional geometry. The variety of work here provided is greater than is usually supposed, and is by no means dry or uninteresting or abstract. Some practical suggestions as to its character may be found in an article contributed to the *National geographic magazine* early in 1900. Let me specially urge on the attention of those who are attracted by this division of the subject the exercises by which latitude, longitude, the length of the year, the obliquity of the ecliptic, and the declination of the sun are determined by the scholars themselves, without assistance from nautical almanacs or other external aids. No high degree of accuracy may be reached, but a real comprehension of these problems and their applications may be gained, such as is never acquired by textbook study.

The atmosphere must be dealt with physically. If the class has not already studied physics, let them get a good introduction to its nature by the measurement of temperature, rainfall and other climatic elements; but in the absence of a good physical basis, do not attempt to explain such problems as the general circulation of the atmosphere; that is impossible. Practical exercises on the atmosphere naturally lead to the construction and study of the weather maps with which this country is so highly favored; climatic charts are also susceptible of much more practical and useful study than is ordinarily given to them.

The study of the ocean is both physical and geometric. This part of the subject should be handled with a light touch: it is not worth while to give elaborate attention to the ocean in inland schools; but, if time is allowed, depths, waves, currents and tides all afford excellent material for practical exercises by which useful lessons may be impressed. A tank in the basement may here be employed to advantage.

The study of the lands must be of a kind that will lead pupils to understand what they see in a landscape. For this reason, continents, mountain ranges and plateaus are too large to serve as units. The items that are studied must be small enough to be seen, for it is only by putting together visible units that a good idea of larger areas can be gained. The units must be studied rationally; shown to be the product of ordinary processes, not ready-made articles or the results of a mysterious past. All exercises on land forms should be directed to this reasonable end, not only for the sake of impressing a great truth regarding physiographic development, but still more for the sake of enabling the pupils to see things better. There can be no question whatever that observation is aided by intelligent understanding. Much of this part of the work, indoors and out, must be of a nature that is by many called geologic, though it is not altogether clear why geographers are so generally content to leave to geologists all treatment of matters so eminently physiographic as the weathering of rocks, the wasting of soils, the transportation of land waste by streams, the abrasion of land margins by sea waves. If these activities had occurred only in the remote past geologists alone might lay claim to them; but, as a matter of fact, they are all part of the very living present. A geographer might almost as well be ignorant of the downstream direction of river flow as of the downstream transportation of land waste. From the very first teaching of geography, the young pupil should regard a river as the discharge of the water and the waste of its drainage basin, not of pure water alone, though the ordinary definitions might give him that idea. It is chiefly in this connection that field work is so useful. Children may naturally enough believe that weathering and erosion take place only in books, if they are never led to see the commonplace operations of these processes in the home field. They may reasonably infer that the physiographic development of land forms is an abstraction, if they are never shown the results of such development in the hills and valleys about their home. All the habitual activities of the lands should be studied outdoors. Farther illustration of certain processes should be given in the school basement or the schoolyard with clay or sand and a hose. Maps, models and pictures of the land forms that have been fashioned by these processes, as well as the briefest series of minerals and rocks that chiefly make up the lands, may be studied in the laboratory.

A well founded belief in the reality of geographic facts is one of the smallest of the good results that follows from the performance of field and laboratory work as contrasted with recitations from a text. Greater and better results are the development of an intelligent self-confidence in the place of a too docile submission to a printed statement; the discovery by a young pupil that he or she is, like the author of the textbook, a reasoning being, capable of finding out things by looking and thinking as well as by reading; above all, the formation of a habit of appeal to the facts of nature by direct observation in order to lay the foundations of science, and of appeal to reason in order to find out the meaning of the facts. If the study of geography is to serve for the education of something more than postoffice clerks and express messengers, if it is to contribute a proper share toward the development of intelligent citizens, then the attention that is now sometimes given to the names of the counties along the southern or eastern boundary of a state should be relaxed, and fuller attention be given to the observation of facts that have a more enlarging interest and application.

Though it is physical geography in the high school that here takes our attention, it should not be forgotten that many exercises of a practical nature should be given in the lower schools. The observational determination of the length of the year, of the mean temperature of a month, of the weathering and washing of land waste ought to be made before the high school is reached. Then the pupil in the high school can do something better; for example, he can by observation and correspondence determine the difference of longitude between his school and some other school; he can similarly measure the size of the earth, measure the inversions of temperature that occur during anti-cyclonic winter weather, discuss the development of land forms as affected by the wasting and washing of their rocks. Before a satisfactory scheme of high school exercises can be planned, appropriate schemes for the lower schools must be adopted: and, if this state association desires a useful task for some of its members, let a committee be appointed for the more precise formulation of the physiographic work that ought to be done in successive school years. Let me counsel such a committee to be ambitious, and not to content itself with recommendations that can be immediately carried out, but rather with such as will call for some effort on the part of the average teacher. Let us compare notes on the results of such efforts 10 years hence. In the meantime, it is evident that much educational waste can be stopped by a well arranged scheme of work for successive years. Each year should include the work best adapted to it; older pupils will then not have to do elementary exercises. The work of each year will be usefully built on by the work of later years; it will thus be kept as fresh as possible in the pupil's memory. No work will be unnecessarily repeated, and valuable scraps of time will be gained in an economy of this kind. Coordinated work is as important in practical physiographic exercises as it is in arithmetic, algebra and geometry.

An important question is encountered in considering the equipment of a high school for good practical work in physical geography. We must all agree that the first item in the equipment, ranking above laboratory and apparatus, is a good teacher; and by a good teacher, I mean one who has, among other things, actually performed a large variety of practical exercises, has really learned what field work means, and is competent to explore a new district and to discover its field resources in so far as they are related to school teaching. If I may judge from the teachers who have attended my summer course in geography at Harvard during the past five years, such preparation is rare, because of the novelty of practical work in geography. There is plenty of interest and capacity, but little experience or confidence. We must wait for about two school generations—about 20 years—before such preparation will be general, and we may not always find it even then. The best thing to do now is to give existing teachers every chance to improve themselves, and to give intending teachers every encouragement to make serious preparation for their future work.

The material equipment of a physiographic laboratory is today under active discussion. There is no standard equipment yet devised. There is at present no school-furnishing firm ready to supply a complete set of materials, all prepared, leaving the teacher only to make such additions as will serve his individuality or his locality. Here is room for enterprise. In the meantime, we should all expect to find globes and wall maps in a geographic laboratory or classroom; it is now coming to be customary to find also certain large scale maps, such as are published by our government bureaus, and an occasional model; but, when it comes to details, it is evident that the practical exercises must be first planned, and the materials for their accomplishment must then be secured. Your proposed committee has therefore a double task: first to devise the exercises, and second to devise appropriate materials for performing them.

Before closing, I wish to consider some of the external conditions that will help or hinder the attainment of our ideals. Foremost here is the responsibility of the normal schools. It will be at once admitted that an energetic normal teacher of physiography, well trained in his subject, imbued with the scientific spirit and possessing the teaching instinct, may greatly promote the progress that we have at heart; all the more, if he is sympathetically sustained by the principal of the school to the point of gaining a good material equipment. But I fancy that one of the great discouragements that such a teacher suffers is the ease with which normal graduates imperfectly prepared in physical geography secure positions in our schools.

Hence we must look next to the superintendents or other appointing powers, and urge them to require of a candidate as high a degree of proficiency in physical geography as in any other subject; or, still better, to require a specialization in physical geography of anyone to whose hands this growing subject is to be intrusted in high schools and academies. A conference among normal teachers, superintendents, and masters, to determine what shall be done in the school courses in physiography, and what preparation shall be expected of new teachers during the next five years, would be of value if it resulted in raising the present standards; but it would be a hindrance if it gave authoritative approval to the unsatisfactory conditions now existing and took no steps to better them.

An effective external aid to observational teaching is the preparation of local guide books for field work. The physiographic resources of such a district as that surrounding this city (Rochester) can not at present be so well set forth by school teachers as by experts of a larger experience. Lectures and excursions for teachers, such as have been given by your university professor of geology, are very helpful, but their value would be increased if they could be set forth in printed form with due regard to their actual use in schools. For the object here considered, it is not enough that a local guidebook shall present an accurate account of the home district; the account should be presented in the order in which it will be used in the schools, so that it will serve as an immediate aid in school teaching. A local scientific society could do excellent work in supporting the publication of such a guidebook, and thus it would greatly promote its own success in a later generation of members.

It is very evident, in reviewing the various suggestions here made, that progress means work. Experience shows that coordinated work is more effective than scattered efforts. Therefore, I again urge on this association the desirability of appointing a strong committee to prepare a detailed outline of a series of practical exercises for a course in physical geography in high schools and academies.

**Prin. G. H. Walden**—Yesterday in another meeting I had occasion to discuss the interpretative power of the human voice; and, while listening to Prof. Davis this afternoon, I thought his talk a good illustration of it. Most of us teachers here are familiar with the textbook which was written, I believe, by the speaker; and it is no disparagement to the book to say that many times we teachers have run on paragraphs in it that called for some hard work and special interpretation. Now that we have heard the professor's voice, it seems to me that we can understand that book far better than we otherwise could.

What little I have to say on this paper is said from the standpoint of the elementary schools, which I have been asked to represent. One of the most encouraging signs of the times in elementary school work is the fact that men like Prof. Davis, and others of fame in the realm of science, are willing to get down and talk the kind of talk that we of the elementary schools wish to hear, and propose to us the kind of work that comes within the reach of our activities. It is not very long ago that it was almost impossible for us to get such consideration as we now receive. As these men tell us of the equipment necessary to carry out this kind of work, we oftentimes become discouraged, specially when our work is thrown into comparison with the work of high schools and colleges, and we see what these institutions have in the way of equipment to help them. Now this idea of a laboratory in a school building seems to me to be just as practical in an elementary school, in a grammar school, as in a high school; and I often wish that the hard-headed business men on boards of education could listen to these men, listen to the instruction that is oftentimes given to us teachers, and put themselves in our places. Does any teacher here doubt for one moment that both children and teachers would be in almost a state of ecstasy, if they could have a room for a laboratory, and go there and do the work that comes within the understanding of the elementary school boy and girl? I have never heard of such a thing. I have seen a little corner of a hall where there would be sand tables perhaps, but not such an equipment as Prof. Davis has mentioned. I believe most sincerely as an elementary school man that much of this work ought to be done in a laboratory; I believe emphatically in making physical geography a part of the elementary school course from a very early age. I have been interested also in nature study. It is generally conceded by psychologists that there are two conditions that young children should come in contact with in observation. One is that the thing should be large, and the other that it should be active. Now take nature study as it is commonly taught in the lowest grades. Take the flower from some plant, dissect it, and learn the names of its parts, as is often done. Such small, painstaking work can not hold the children's attention long. Now, on the contrary, take them on a walk and point out the physiographic features that come within the reach of their understanding, and in a moment they are captured. There are teachers here who have been out with their classes; and, I think, they will testify that, if they themselves are prepared in advance, they have little difficulty in teaching the lesson of the occasion. I favor geographic nature study; and I would have the greater part of nature study a matter of developing better knowledge of surroundings in general, and not so much a thing of detail, with young children.

In listening to this paper I was specially struck with the flat roof idea. That of course could be considered in the matter of building and equipping a new school; and in large cities, where playgrounds are the exception rather than the rule, it would be, as suggested, a place where observations could be made and where things could be left without danger of molestation. There would be no disturbing conditions, such as occur frequently in schoolyards, specially those that have no fences. As regards the study of the topography of the school district, in the city that idea is practical, and is usually, I think, carried out by the teachers who are interested in this branch of the work.

It would be useless for me to try to go through the various points of this paper that we have just listened to, and attempt to show what particular relation they bear to our daily work here in the city. I should like to say for the benefit of any who are here, and are not acquainted with our school system, that there has been in progress for several years that change that Prof Davis is willing to give so much time really to accomplish. Nothing that he has said this afternoon has given me more pleasure or more courage than that he is willing to wait two generations for progress. I have one word to say here, suggested by the very fact of the gentleman's reading this paper. There has been unfriendly criticism on both sides, on teachers and on professors of various subjects, with regard to keeping up with the times. It is a more difficult task than one outside of the work is willing oftentimes to admit. For the teacher who has taught several years acceptably, to begin anew to study and to study something that was not taught in the schools when she was prepared and trained for teaching, is no easy matter. It is very difficult for one who is teaching her full time to find time to take up these subjects. Yet in reason we, as teachers, must admit the necessity of this progress, and in a measure we are making it. We need sympathy and help. The day is fast approaching when science will enter into every department of learning. The word, scientist, will in the future, I believe, be applied only to men of the very highest rank, while as now used it is a general term for all interested in the work. We must all use our eyes. I was delighted to hear the professor say that intelligence counts for more than mere information. None of us doubt that, though there have been times when our practices in teaching have been the other way.

**Prof. I. P. Bishop**—I have been much interested in the discussion. I am one of those who believe that the teaching of all geography should be from the physical standpoint. Perhaps I should go a step farther and say that it should always have a basis of geology, or at any rate, a little geology should form a part of the teacher's outfit.

The first essential in the teaching of physical geography, as in the teaching of anything else, is the teacher. Next to that is a proper amount of time. Laboratory work means extra labor, extra hours in teaching and extra hours and labor in collecting an outfit. With eight subjects to teach and physical geography among them, is it to be wondered at that the teacher shrinks from this extra drain on his energies? His hours of work should be lessened, and he should have freedom to use the kind of knowledge in which his previous training has been richest. My friend, Dr Kales, is a weather man. He studies the atmosphere, is wise in meteorologic lore, has an amateur meteorologic outfit; and, if he were teaching physical geography, would probably give a large part of his time to that subject. His pupils would profit by his knowledge and enthusiasm and become weather observers, much to their advantage. My predilection would be toward the geologic side, because it is one of my recreations to study nature from that particular point of view. Dr Kales uses the atmosphere which he has always with him for teaching material. I use dirt and stones, the pavements and plowed fields for the same reason, that they are always accessible and interest me.

The great principle is to teach nature as you find it and use the material nearest at hand. In the city the teacher is handicapped by the fact that the out-of-doors has been encroached on by buildings and other things. It is very seldom that we have a piece of land near the school which would furnish illustration of relief or drainage. But the country school teacher always has these at his door. A heavy thunderstorm gashes a plowed field with minature ravines and spreads the material out lower down as a delta or flood plain, and you have the model of a river system. That is the best possible laboratory for the child and for the teacher.

I speak of the geologic side as important, because an apparently insignificant geologic cause may account for facts at first sight entirely unrelated to it. A little ledge of hard rock in the bed of a stream makes a fall: this determines the site of a mill for grinding or sawing; a store for selling necessary articles follows; then a blacksmith shop for shoeing horses and repairing iron implements; the inn, the church and the school become necessities, and we have the village, the town or the city, as time or circumstances may determine.

Thus we see the relation between remote physical causes and existing social conditions. Nearly every small town and many large ones have facilities of this kind, which I believe to be the best demonstration material in the world as far as it goes. The really good teacher will use such means and will gather about him other appliances for making the study interesting. The city high school teacher, who has no such natural advantages at hand, must create for himself artificial substitutes. For him the physical laboratory is a necessity.

**Prof. William T. Morrey**—I ask my pupils to describe their experiments under the headings 1) purpose, 2) materials, 3) method, 4) results, and 5) conclusions.

1 *Purpose.* I desire to comment briefly on the work and the experiments by and on the classes in physiography in the Peter Cooper high school of New York city.

2 *Materials.* a) *Pupils*, about 150, ages 16 to 17, four fifths girls; little close acquaintance with natural phenomena.

b) *Course* required in third year of those expecting to become teachers, elective by others. Botany, biology and physics have preceded it. Periods, four a week, 45 minutes each, one of four is " unprepared " work. " Unprepared " work, an exercise, an experiment, supplementary reading, or oral or written review, at discretion of the teacher.

c) *Equipment* fair, perhaps much better than the average. We need, of course, many more maps, charts, apparatus, and models; most of all just now we need the Shaler-Davis-Harris models and photographs for physical geography and geology.

d) *Textbook.* Prof. Davis's. Some 50 standard reference works. For supplementary reading and " unprepared work" copies enough to supply at least a large class with the separate monographs of National geographic society and some of the Cornell nature study quarterlies.

e) *Excursions.* So far we have visited the sidewalk in front of the school and a small outcrop of Tuckahoe limestone in a nearby lot. We hope, of course, to make use of the large parks, the Palisades, the sea beaches, tidal marshes, and the great museum of natural history.

f) The ***principal*** and the ***head of the department*** designated the results desired, advised when requested, but generally left methods to the teachers.

g) The ***teacher*** has tried to keep abreast of new ideas and points of view, and of recent literature without being carried away by them.

3 *Methods.* The text must be understood, principles mastered, illustrative facts learned, and the main things must be drilled in. Examples and illustrations should include the commonplace, the merely local, the state, the national, and then the continental.

Experiments made where unavoidable rather than whenever possible, few rather than many, always as a means not as an end. When in doubt about the value of an experiment or exercise, do not make it, review instead.

Comprehensive *reviews* showing the interrelationship of the various phenomena, in concluding a subject. Articulated skeleton outlines.

The pupils must be prepared to pass a good, stiff examination on their textbook.

4 *Results.* Probably very few pupils will not deserve promotion.

The results of the first three experiments were the poorest because they were assigned for home work rather than class work, because too long a time was given in which to do them, because they were given together instead of separately, and because they may not have been clearly explained, or were in part too difficult. The test of a paper's value was this: could a third person of ordinary intelligence take the paper and from it learn how to perform the experiment proposed, obtain reasonably accurate results, and draw proper conclusions. On first trials the results were these: 75% could describe how to locate the meridian through some particular place from noon shadow; 38% located meridian by comparing equal shadows, etc.; 28% found their approximate latitude north of the place where the sun was that day overhead.

The results of the excursions were apparently satisfactory as to fall line, stream banks, talus, weathering, joints, etc., even if one girl when the class was standing by a dried-up pool said she was looking at the " crater of a volcano ".

Analogies and illustrations sometimes led to unexpected results. In studying mountains, arched, block, and domed, the pupil was asked which class was represented by the top of one's head, with its successive layers of strata of bone, muscle, and skin. The head in question seemed to the pupil to be neither domed nor arched.

5 *Conclusions.* "We learn to do by doing ". There are many things that can be learned best and most quickly by means of experiments. One of the greatest needs just now in the teaching of physiography in the secondary schools is a good, well planned, well digested collection of experiments or exercises. Not a few of the exercises proposed in some of our periodicals are not worth the doing. They may serve to count toward a certain required number, or to consume time, or to keep pupils out of mischief, or to pad out notebooks, but they impart neither knowledge nor power. Let us at least occasionally presume that the pupil has some common sense. He does not enjoy your demonstrating to him the obvious.

The most valuable exercises are those that give the pupil understanding and appreciation of the physiographic features of his own immediate neighborhood. If he understands his wet weather stream and its gully in the clay bank he has the keys to the problems of the Mississippi, and to those of the Grand canyon of the Colorado. These outdoor lessons can be arranged for by assigning the last period to different classes on different days. As aids to an appreciation of the commonplace I have supplied the classes with the Cornell pamphlets, the *Brook* and the *Soil.*

Every community should have its local text and guide book. The Worcester natural history society published in 1898 Joseph H. Perry's *Physical geography of Worcester, Mass.* In 1899 the Geographic society of Chicago, Prof. R. D. Salisbury and W. C. Alden's *Geography of Chicago and its environs.* I feel that I should undertake something of the kind for Greater New York.

The physical features of every state should be described and presented in attractive form. Some of the state geologic surveys have not been idle along this line, as witness Prof. Salisbury's *Physical geography of New Jersey,* Prof. Abbe's *Physiography of Maryland,* and Prof. Marbut's *Physiographic features of Missouri.* On the physical geography of New York state there is little accessible. Prof. Tarr's 12 articles in the bulletin of the American geographical society (11 W. 29th st., New York) are the most valuable. These articles are scattered through some five years, and in 12 different numbers. Their rarity and the price ($1 a number) place them beyond reach of the average teacher. I hope that the articles will be reissued in more convenient form. I suggest that this association urge the regents of the University to take this matter up and to give these articles by Prof. Tarr the form, the rich illustration, the nominal price and the wide distribution which their excellence deserves. We are all grateful to the regents for Dr Merrill's *Guide to the study of the geological collections of the New York state museum.* The wide distribution and the general use of these two books will awaken interest, arouse enthusiasm, and promote the study of physical geography in the state as no other means will.

**Prin. Frank Carney**—I simply wish to make a suggestion. I believe that the earth science teachers of New York state are at present numerous enough possibly to agree on something definite, so that, when the school boards, even if they contain a few members such as the gentleman has referred to, ask what we want in the way of physiographic material, we shall have something to say. If the question should come to some teachers in New

York state, the school board would get a particular answer. If the school board of this city should put the same question, it would perhaps get a different answer. And so it goes. The point is this: what we need is some uniformity, some definiteness. We need something, as suggested by Prof. Davis, in the way of a set of exact exercises. The history teachers in our schools learned this fact some time ago, and, through committees appointed, they have now got down, I think, to a basis of agreement; and so in other departments. I suggest now that the earth science teachers of this association appoint a committee which shall report at our next annual meeting. One of the vital matters touched on in this little syllabus of Prof. Davis's paper is this: the importance of so correlating work of successive years that one shall prepare for the next; that the preparation thus made shall be fully used and built on; and that no unnecessary repetition of work shall be allowed. Without some consensus as to where we are at, this is never possible; till we have a consensus as to the correlation of our work, we shall never get it.

——— I want to say a word about these topographic maps. I remember a few months ago hunting up an office in Berlin because I wanted to buy about five German atlas sheets. They came to nearly $5 if I remember correctly. For about twice that amount I had bought two or three years ago the whole outfit of sheets furnished by the United States survey. Now I do not suppose you are going to buy 1200 or 1400 sheets, many of them very small, but you can take the little pamphlet by Prof. Davis, on the *Use of maps in schools*, with the maps that have thus far been issued for wall study, and have a very good outfit for practical work so far as these maps go, putting them into new folders classified and labeled. I have taken the little manual prepared by Prof. Davis, cut up copies of it and pasted the descriptions at the bottom of the maps for certain uses. Another good scheme is to mount a part of the maps and group a number of sheets that show some important feature. These might perhaps be colored, strengthening the drainage lines or bringing out some other important feature. Another suggestion. When you have mounted a map, do not hang it up where the pupils will see it all the while. Roll it up when you are through with it and lay it away, bringing it out only once in a while. Make all of them more or less rarities and let them be fresh to the pupils.

I remember spending some time about 11 years ago in the Harvard summer school and listening to Prof. Davis. I was indebted to him that summer for an impression, which was ground down into me so that it stuck, that, in making a geologic section or in diagraming a cross-section, the diversified topography should be preserved and the vertical scale be kept down. I state this here, a little out of place, but I wish to pay my measure of compliments to Prof. Davis.

**R. H. Whitbeck**—Let me say first that there is available a collection of lantern slides such as Prof. Davis regretted did not exist. Cornell university has between 2000 and 3000 lantern slides very carefully collected, and the authorities of that institution have consented that duplicates of these lantern slides may be sold. There is a man in Cornell now who can supply you with an illustrated catalogue and prices of lantern slides covering practically every topic in physical geography, and will provide you with them at a rate lower than dealers get. This is done by the courtesy of Cornell university to help along a good cause.[1]

The second point is this. There is being prepared a physical geography guide for New York state. Perhaps I am a little premature in announcing this, for I only heard of it a short time ago; but one is, I believe, in preparation. It is intended to be a guide for the use of teachers of physical geography in New York state.

The third thing is that there is a possibility of Prof. Tarr's articles on the physical geography of New York state being collected and published in a single volume; and I would like to make a motion right here to this effect, that Prof. Tarr be encouraged by a vote of this meeting to collect and publish in one volume his articles on the physical geography of New York state.

Mr Whitbeck's motion was carried unanimously.

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[1] Farther information may be obtained by addressing Prof. R. S. Tarr, Cornell university, Ithaca N. Y.

**Prof. Davis**—It is evident from what has just been said that more advance than I recognized is under way. I hope, however, that, when the catalogue is printed, not merely will these 2000 or 3000 slides be given, but a selection of the best 50 will be made for illustrating geography in the grades and a selection of 100 for geography in the high school. It is desirable that the teachers be aided in selecting from the blue prints by experts. I am sure the teachers would be very glad to have such aid, so that they might say, "Give me the 50 or the 100", rather than have to make the selection for themselves.

Another word in regard to the laboratory versus the field. It does not seem to me that either one can be dispensed with in any locality. The local field, however varied, is not the earth; it lacks many important things, and some observational experience in those other things can be gained best by laboratory work. On the other hand, however good the laboratory, however full its equipment, we can not dispense with the field, because we can never hope to give in the laboratory the training that the field can give.

As to the burden on the teacher. I hope nothing that I have said will imply that I am not aware that teachers are very hard worked; that as a rule they have too many different things to do, too little leisure for study, pay insufficient to enable them to carry on outside work. These are some of the serious difficulties under which education in general labors today; we must recognize them and strive against them. Not only must superintendents, when appointing new teachers, select the very best they can get, but they must also give an opportunity for progress to teachers who are already appointed. A scheme by which opportunity for progress is furnished is actually in operation in the city of Indianapolis in connection with what is there called the Gregg fund. The Gregg fund is some $10,000 or $15,000, the gift of a former teacher in Indianapolis, who on leaving that city went west, and, remembering his former associates, left a considerable sum of money for the benefit of the public schools of Indianapolis. The superintendent there was at loss for a time to know in what way a sum so munificent could be best applied to the benefit of the schools. After waiting some time, during which the fund accumulated, it was finally decided to apply the income to scholarships for the teachers in the schools of Indianapolis and thus to enable them to go away for half a year or a year for purposes of study. In that way many teachers of Indianapolis have had opportunity of liberal study in colleges and universities and have profited greatly. They are asked in return to pledge themselves to service in the Indianapolis schools for a short period of years. It is curious that so simple and so admirable a scheme as this is found in only one of our many cities. It is curious that, with so many extremely generous givers, this simple scheme is practically unknown. We hear over and over again of the successful man who has come up from the country giving his home village enough from his competence to maintain a free library, for example. But, supposing another man goes out from that village, what shall he do? Might not he give a Gregg fund, the income of which would greatly supplement the efforts of the superintendent in enabling the teachers to improve themselves? A Gregg fund in a country village would in the course of six, eight or 10 years complete a circuit among the teachers. It would be an invaluable aid to teachers and thus of great advantage to scholars.

## SECTION D. NATURE STUDY

### SIGNIFICANCE AND LIMITATIONS OF NATURE WORK

BY PROF. STANLEY COULTER, PURDUE UNIVERSITY

[Paper read but manuscript not received at date of printing]

### SYNTHETIC NATURE STUDY

BY SUP'T HENRY A. KELLY, NEW YORK

Within the last few years nature study has been introduced into the curriculum of the elementary school. It is coming to be recognized as an important factor in the education of young children. The problems which now press for solution are those connected with the character of the nature study and with its educational value, on the one hand; and with its relation to the other subjects of instruction, on the other. While these can not in reality be considered apart, it will be found convenient to attempt a discussion of them separately.

We have first to decide as to the aim of nature study in elementary education. The object at which we aim in education can not be expressed in terms of the separate subjects concerned. Thus the statement of what we hope to contribute to the child's development by nature study, considered as a separate branch of instruction, must of necessity be narrow and inadequate. It will, however, serve to bring certain peculiarities into stronger relief, besides clearing the way for discussion, if we note the aim as expressed by some of those who have given attention to this matter recently.

In the preliminary report of the committee of nine of this association, printed in the *Journal of pedagogy*, April 1898, it is said:

> The specific object of nature study, we think, should be to train children to see, to think, to talk, to write, or in more general terms: first, to get knowledge by the thoughtful observation of real things, and then to express it naturally and correctly. But besides these specific objects, there are others of a more general character and of higher order: to cultivate sympathy with nature and appreciation of her beauties, skill in the use of the senses, and judgment in the translation of the messages they deliver, and finally, above all, to secure a correct attitude of the child mind toward knowledge in general.

The report of the subcommittee on nature study to the committee of nine, published in the *Proceedings* of the third annual conference of this association, November 1899, says:

> The immediate aim of nature study in elementary schools is quite different from the object of science in higher institutions. While both nature study and science should train pupils to use their eyes and other senses, and thereby gain definite exact knowledge, and should develop the powers of observation, thought and expression, the teacher of nature study must give attention to the mental interests of boys and girls, and endeavor to quicken their reverence for nature and appreciation of the beauties of the world of sense. Nature should be a means of training our children not merely to see, think and tell for themselves, but to appreciate what is most worth seeing, thinking about and expressing.

In the report of the committee of 10 the aim is thus expressed:

> It must be remembered that the primary object of nature study is not that the children may get a knowledge of plants and animals. The first purpose of the work is to interest them in nature. The second purpose is to train and develop the children: i. e., to train them to observe, compare and express (see, reason, tell); to cause them to form the habit of investigating carefully and of making clear, truthful statements, and to develop in them a taste for original investigation. The third purpose is the acquisition of knowledge.

These are typical of many other expressions on the subject. Their general similarity of thought will be noted, though the emphasis is differently placed. In all, however, the need of interesting children in nature, and of establishing sympathetic relations between the child and nature is recognized. A restatement of these aims may be attempted by saying that the nature study should conserve and extend the child's interest in natural phenomena and the relations existing between them, should develop a sympathetic appreciation of living creatures; and should utilize these interests in forming habits of observation and comparison, in promoting rational organization of ideas, and facility and correctness in artistic and vital expression. Nature study as thus understood includes not only the work on plants and animals, and inorganic nature generally given in the lower grades, but also the study of those more definitely physical and chemical phenomena which may be introduced into the higher grades to enrich the geography work.

With this general aim in mind, and with the qualification already pointed out as to its inadequacy of expression, we may consider what principles are at hand to guide us in deciding what nature study is of most worth. And here we have a choice of two courses—we may enunciate the principles empirically determined by the teacher in the classroom, or we may seek in biologic and psychologic science for some broad generalization. The first course is open to the objection of being unscientific. The principles discovered by it have no necessary validity. We are, moreover, provided with a scientific generalization of the greatest value, as expressed by Herbert Spencer, " Mind rises to what are universally recognized as its higher developments in proportion as it manifests the traits characterizing evolution in general ", that is to say, mental development from its earliest beginnings is to be recognized as " a correspondence between inner and outer actions." Progress in education, as in biology, depends on successive adaptations of the organism to an increasingly complex environment.

It is a peculiarity of nature study, understood in the broad way already outlined, that it is able to furnish knowledge of a large part of this environment. It is certain that we have not utilized the opportunities offered for a wide contact with reality in a generation which, as Prof. Geddes says, " has been so largely trained to mental activity in presence of the printed or written word, but to mental passivity, if not indeed to complete repose in the open air and in presence of the facts themselves." The fault lies largely with our school training. It is a fault which nature study properly taught can remedy.

But it is not enough that the environment be presented to the pupil; it must be presented in such a way that by successive adapations, or reactions, growth may take place. In a word, mental organization must be provided for, and this can be done only by methods which result in mental synthesis, or in Spencer's term integration. He says:

> After there has been a mental accumulation of facts presenting a certain community of nature (remembered first as isolated facts, and after further experience colligated as facts having some resemblance) there, suddenly, on the occurrence perhaps of some typical example, arises a cognition of the relation of coexistence or sequence common to the group: the particular facts, before loosely aggregated, all at once are crystallized into a general fact—are integrated.

It is, I believe, a fair criticism of much of our own school work, not alone of nature study, that it fails to provide for synthesis of elements—for mental organization, which means power for development. By this it is not meant to undervalue the importance of analysis and isolation in school work. The first procedure of the mind, as Sir William Hamilton has pointed out, is analytic. Analysis and synthesis are correlative processes and go together. But it undoubtedly remains true that the emphasis is laid on analysis in much of our school work. The teacher, who is an artist, aiming at the development of creative power, needs to appreciate more fully the importance of definite artistic and constructive work. It is here that the failure of the object lesson system, which flourished in the days of a psychology of faculties, comes most clearly into view. No synthesis was possible on account of the widely dissimilar objects chosen for study, the principle of whose choice was merely to provide material for observation and analysis. There is danger, too, in the exclusive use of the laboratory method, which may neglect to bring the facts learned into proper relations. This was clearly shown in the early days of the laboratory method in high school physics.

On the other hand, there is evidence that the importance of a more synthetic mode of treatment in teaching is beginning to be appreciated. A few illustrations will serve to make this clear. Among the broadest educational influences of the day, reaching all classes alike, are those great expositions which have been so pronounced a feature of late years, in this country and abroad. In the development of these great undertakings we are able to note a decided step in the direction of a more synthetic mode of treatment of the exhibits. Without being able at this time to point out in detail the steps in the development of this idea, it must suffice to call attention to the commendation expressed by Prof. Geddes, of the idea of the Swiss village, a side show, as we should say, of the great Paris exposition of last summer. In a recent article in the *International monthly*, he quotes from the guidebook of the village as follows:

> The designers have wished to make more than a Swiss village; their aim has been to realize the synthesis of an entire country, to give material expression to a whole nature. They have taken

a hostelry at Lucerne, a house at Berne, a chalet at Brienz, and so on; and they have united, grouped and fused these elements, apparently distinct, but really proceeding from one characteristic and general type. In the same way they have taken here a peak and there a pass, there a grotto and there a rock slide; they have planted the pine, the fir, the juniper; and out of these elements they have made something which is Switzerland as a whole, which sums up its very spirit into this synthesis of landscape, architecture and life; and they have thus made their village the expression of their love and devotion to their native land.

And in commendation of the spirit in which these builders worked, Prof. Geddes says:

To the writer, of whose own life pilgrimage and its resultant ideas this ramble from the Sorbonne to the Louvre, and thence through the exposition to the Swiss village has been a kind of summary, the success of this union of sociology with art appears so complete as amply to justify the apparent paradox of putting this popular show at the climax of a pedagogical scale, of which the upper grades are best represented in the exposition; while the schools and universities are still only at the beginning.

The great museums fulfil more permanently, if within narrower limits, the functions of the expositions. Here the arrangement of material is still largely analytic, but a change in this respect is to be discerned. In biologic collections the organism is no longer shown merely as a dead and ticketed specimen of a certain genus and species, but in relation to its environmental conditions as well. In the American musuem of natural history in the city of New York are cases containing birds and mammals mounted amid artistic and correct reproductions of their environment; here the male robin and oriole are perched on the branch above the nest, while the female is busied below; there a herd of bison roam the prairie, or a family of moose hide in the depths of a northern swamp.

In one room in the conservatory at the Bronx botanic gardens in the same city is grouped a collection of xerophytes from all over the world. Here one sees repeated the various modifications due to the conditions under which these plants are forced to live. Here are euphorbias and cacti with spiny armature; there waxy blooms and hairy coverings, and reduced leaf surfaces tell the same story of economy in the water supply. In the zoologic gardens in the same park the home environment is reproduced as nearly as possible for the living animal. The wolf has his den in the rocks; the woodchuck ground in which to burrow to his heart's content; the deer and bison great ranges to wander over.

The biologists have found their latest problems in animal and plant oecology, and their interests are reflected in the schools. A comparison of recent high school textbooks in biology with those in use even five years ago, will show how profound the change from the old anatomic and classificatory analyses is. The effort is now to know the organism as a whole, living its life in its own way, and profoundly modified by the conditions of its environment, which themselves have to be understood to understand the organism properly. The oecological and synthetic side of the study is put forward as of first importance. Thus Prof. Jordan, in the preface to his new *Animal life* says:

> The beginning student should know that the whole life of animals, that all the variety of animal form and habit, is an expression of the fitness of animals to the varied circumstances and conditions of their living, and that this adapting and fitting of their life to the conditions of living come about inevitably and naturally, and that it can be readily studied and largely understood.

Prof. Coulter, in the preface to his *Plant relations*, bears testimony to the same effect.

In the elementary school also there are signs that the same leaven is at work. This is seen in the introduction of the term, nature study, in place of the old object lesson, or elementary botany and zoology. The very nomenclature demands the recognition of the synthetic principle, without this the lessons are merely plant or animal lessons. The same principle is beginning to be recognized in the relation which manual training is coming to have to the other school work, and in the correlation of nature study with manual training and literature. The growing appreciation of the value of excursions to the country, park, museum, menagerie and factory is also a promising sign pointing in the same direction.

It is to be noted in passing that interest in school work is provided for by the recognition of this principle. Here we have to distinguish between interest in the objects presented for study, and interest in investigation, in the discovery of relations, in the synthesis accompanying properly directed mental activity. Children are natively interested in nature, specially on the sides of life and movement, and utility; but, even if they were not, it would still be possible to secure and maintain a high degree of interest in school work in this subject by a synthetic mode of treatment.

So far the attempt has been made to present the arguments for the recognition of this principle from the standpoint of nature study as a separate branch of instruction. But, as has been seen, it is impossible so to consider it for any length of time. The question of the relation of nature study to the other branches is bound to arise. Correlation has sometimes been attempted by synthesis of studies which should properly stand apart. This form of correlation overlooks the value of isolation, and is the form which Dr Harris criticizes in the report of the committee of 15, in which he speaks of the use of DeFoe's *Robinson Crusoe* for reading, arithmetic and geography lessons, as follows: "If the material for other branches is to be sought for in connection with the literary exercise, it will distract attention from the poetic unity. On the other hand, arithmetic and geography can not be unfolded freely and comprehensively if they are to wait on the opportunities afforded in a poem or novel for their development." Time is lacking for the discussion of all the points which might arise in the application of this principle, but in general it may be said that nothing should be considered in the way of correlation which interferes with the free development of nature study along the lines already suggested. That the subject is given a place in an already overcrowded curriculum suggests that it has its contribution to make to the development of the child. The union between nature study and the other branches of instruction should be symbiotic, not parasitic. Specially productive of good results, it may be said, are the relations established in some schools between nature study and literature in the lowest grades, between nature study and local history and geography in the intermediate grades, and between nature study and geography in the higher classes.

The other form of correlation which results from the synthesis of controlling ideas, within the limits of a single subject, is the form which has been insisted on throughout the greater part of this paper. In the biologic branches, this synthesis may be brought about through the unifying power of modern views of organism, function and environment; in geography, itself a complex, unity may be secured through recognition of the relations of human organization to environmental conditions.

The principle of synthetic treatment has already been shown to have wide application beyond the limits of the elementary school. It is to the high school and university, building on the firm foundation of the lower grades, that we must look for its more complete development. Each onward and upward step in our education brings wider vistas before our view—what before we saw in the valley as unrelated elements in a sequence of time and space, seen from the hight are blended into one landscape, each separate part softened by the distance and brought into relation to the whole. The trees under which we played as children, the minerals, or insects, or plants which we collected, studied and exchanged in our youth, were all so many separate worlds to us then. If we see them now with the eye of a true student of nature, we appreciate them no longer for ourselves alone, but for the light they can throw on the great problem of man and his relations to the universe.

What seemed the parallel lines of our high school work in the sciences, in mathematics, in history and in literature, are in adult life seen to be focused on the same problem. And this is the final word—to this it must come in the end, that all our science work from the nature study of the elementary school to that other nature study of the high school and university, must aim to contribute its store of related facts, to the end that the aim of education may be realized in better equipped human beings, better morally, esthetically and intellectually. Science is not a collection of scraps of knowledge, of informational odds and ends, but, as Geddes says, "a rational presentment of our facts as a living and dramatic unity, as an historic and organic growth, as an unfolding from simple to complex."

**Prof. J. H. Comstock**—When I read in the program the title of this paper, it roused my indignation and wrath. The idea of synthetic nature study is a red flag to a university man. We who were pioneers in this work and led the early struggles with its difficulties, soon came to an understanding that pupils of nature study should be given but few things. Prof. Jackman, in his book, carries the matter to an extreme, and attempts to teach the rudiments of all the sciences. The child's mind is not synthetic. Prof. Kelly's paper was an excellent and instructive exposition of oecology. I am pleased to find that we are in such hearty accord.

**Prof. Stanley Coulter**—I find that we are in unison in our ideas and differ only in the expression we have given those ideas. I object to a formal method and also to a course of study in nature work.

**Inspector C. N. Cobb**—The teacher who has determined to accomplish definite results will employ the right method naturally.

I believe that nature study can be related closely to the literature work and make the study of poems and of prose writing more interesting and full of life. The pupils can not be held closely to a definite course. It is distressing to the children. The teacher should follow the interests of her class in her selection of topics for study.

**Prof. H. A. Kelly**—I alluded in my paper to the work which is done in many schools in teaching *Hiawatha*. The pupils read the story and at the same time study the plants and animals which are mentioned in the poem.

## GENERAL SESSION—SYMPOSIUM

## COLLEGE ENTRANCE DEMANDS ON THE SCIENTIFIC STUDENT

**Prof. C. W. Dodge**—We are somewhat delayed in beginning the session; but we are having so many good things this afternoon that I am not at all surprised that you wish to linger over them longer than the program requires. Among other suggestions which came in for topics of discussion at this meeting is the one on the program, on which we expect to have four or five addresses from three to five minutes long. The topic is, "What does the college instructor want the scientific student to know and to be able to do when he enters college?" These speeches are quite impromptu. Several gentlemen who have consented to speak have hardly had opportunity to get the topic in mind. After one or two announcements we will begin what has been called, for the lack of a better name, a symposium.

I suppose there is no one science in which preparation is required that compares at all with physics. If any scientific work is required for entrance to college, it is almost certain to be in physics; and Prof. Nichols of Cornell has generously agreed to start the discussion by telling us what he at least would like a student to know in physics when he comes to college.

**Prof. Edward L. Nichols**—No other pedagogic topic relating to entrance examinations has been quite so thoroughly thrashed out as this one, of the physics requirement for college; so much so, that I feel very sure that I have nothing to add to what has been already, if anything, too explicitly stated in various circulars issued by the National educational association, by this association, by the Physicists club of New York and by the regents. There is no division of opinion on this subject. When we attempt to discuss it, we are all of one mind, so that it comes down to such trivialties as whether the duration of time to be devoted to laboratory practice should be 40% or 45% or 50% or 55% of the total —a question which can not be answered in percentages exactly, but has to be solved by each school for itself in accordance with circumstances. In those circulars it is explicitly stated that instruction should be of three distinct kinds, classroom or lecture demonstrations, by which is meant of course the demonstration from the lecture table to the class at large, quiz work, and laboratory practice; and that the laboratory practice should be quantitative so far as possible. In order to indicate what is meant by laboratory practice, lists of experiments for guidance have been prepared. In some cases it would appear that these lists of experiments were almost too mandatory in their character. I do not know that there is much difference of opinion concerning the value of the lists, but it is unwise to tiè individual teachers down too much in giving a list of experiments. The only point where I have found that there is any misunderstanding whatever in the minds of some is as to what constitutes quantitative work. We sometimes find in reading over students' notebooks that the answer to a problem is stated in a vague way. The observation is recorded, for example, that a gas expands, but there is no measurement of the expansion nor of the change of temperature or pressure; or that something changes color, or that there is a rise of pitch. Many of the books that come to us in connection with entrance examinations are, however, made up of actual physical measurements; and I am happy to say that this sort of notebook is becoming more and more common. Often, it is true, we find only roughly approximate measurements; but still tabulated data which show that the students are required to make readings and from those readings to make computations. It might be worth while to insert in the circulars sent out for the guidance of teachers in the secondary schools, a definition of quantitative work; and I would suggest as a suitable definition the following:

Quantitative work is work in which the pupil is required to record and tabulate numerical data obtained from measurements made by himself and to use those data in the computation of some definite result.

**Prof. W. J. Beal**—With the conditions in our part of the state of Michigan, I should say that, nine times out of ten, I regret that a student has had any botany when he comes to college; but, if one claims to have had botany, I place before him a stage miscroscope with two needles in handles, a pair of forceps and usually a small knife, with pencil and paper and five living plants in flower for him to examine. I examine his notes; and, if he has done well, all right. If he comes to the college, I wish him to be able to use his instruments accurately and effectually. A good deal of stress is laid on the ability to see things correctly. I should like him to be familiar with the buds of plants and growing things and the comparison of seeds, both dry ones and those that have been wet for a little while as well as those that have been wet longer.

In our state we have no money for bulletins on nature study; but at the request of the board I have prepared eight of these bulletins under the head of elementary science. I must apologize to you for their appearance. They are printed by the state at their expense. The type is poor and the paper coarse and heavy, but I should be glad to send them to any one who wants them. My talk in the section has been entitled "How shall a young person study botany?" which is a sequel to the *New botany*, printed in 1879. This *New botany* has been revised two or three times. By addressing the *Rural New Yorker*, New York, you can get copies for 10c each.

**Prof. C. W. Dodge**—If there is any one thing which we are all taught in this state, it is that we must not drink or smoke. I do not know whether Dr Lee, professor of physiology in Columbia university, will have anything to say about that subject or not, but I hope sometime or other we can get out from under the thraldom of the Women's Christian temperance union. I have no fault to find with the members personally, because among them are some of my dearest friends, but I do not believe that they have any right to interfere in educational matters.

Prof. Lee has, I believe, undertaken to speak briefly on what ought to be required in physiology for entrance to college.

**Prof. Frederic S. Lee**—I received the invitation to speak in this discussion only a few minutes ago, and in a moment of weakness I consented. I realize now that the subject is one about which I know very little from experience, since my work is almost entirely with graduate students. I might say, however, a very few words. In the first place, physiology as taught in college must necessarily, from the nature of the subject, be largely physical and chemical; hence a knowledge of pure physics and pure chemistry is quite essential to its proper study. Secondly, the college physiology ought not to be simply human physiology. It should be broader than that. It should be a biologic physiology. Hence some knowledge of the elements of biology, of zoology and botany, is also quite essential to its proper study. In the college, I would prefer to see physiology placed after physics, chemistry, and general biology. But this is not always possible. Where it can not be done, it is necessary that the student shall have studied these branches before entering college.

Regarding the question of physiology in the secondary schools as precedent to college physiology, I feel, as doubtless most college teachers here feel, that I should prefer to take a student who has had no training in this science. My special reasons are these. I do not wish to repeat my paper of the afternoon; but one or two things which I tried to point out are that the secondary school physiology is almost entirely a training in *human* physiology, and a training in the physiology of *organs*. I think this is a great mistake. From such a course the student gets a narrow and incorrect idea of the scope of the science of physiology; and many students, if not a majority, become prejudiced against the subject. I would rather take a student who was absolutely untrained in it, who knew nothing whatever about it, than to take one who was prejudiced against it.

To sum up my views, then, it is very desirable that the student who is to take physiology in college shall have taken in the preparatory school physics, chemistry and general biology, or zoology and botany. A broad preliminary course in physiology itself is not undesirable; but, if the preliminary course is to be narrow, I should prefer to have it omitted.

**Prof. Stanley Coulter**—[Manuscript of remarks not received at date of printing]

———Are we to understand, then, that we ordinary teachers of physiology had better expend as little time as possible on the subject of physiology?

**Prof. Lee**—I can hardly agree with such an extreme wording of the nucleus of my thoughts.

**Prof. William Morris Davis**—In answer to the question, "What does the college instructor want the scientific student to know?" my first point is that he should know how to work. It does not seem very material how he has learned to work, provided that he has really made some substantial progress toward that invaluable end. The second point is that, if he is bent on scientific study, it is well that he should have made some beginning in that sort of study before coming to college, and this beginning should have taught him to see what he looks at, to record what he sees and to think about what he sees and records. Knowing science is impossible without some knowledge of how to work in science. Truly, certain scientific facts may be learned, but they remain mere empiricism if they are not learned by scientific methods. There must be opportunity for observation, involving keen and discriminating eyesight; for expression, involving careful and accurate writing in simple and correct language, as well as effective though simple drawing; and for reflection, involving the various faculties of generalization, invention, deduction, comparison, and judgment. None of these processes need be of an advanced order, but they should be sincere as far as they go. Their value is best judged by the student's capacity to undertake work of a similar character rather than by his capacity merely to repeat what he has done or by his memory of itemized statements: hence college examination papers as well as courses of school study may need revision. I can not understand why any college instructor should object to preparatory training of this sort for his students: indeed, it seems as if the objection to preparatory scientific study that has been made by some of the previous speakers this afternoon were based chiefly on the assumption that such preparation must be bad; the sort of preparation, for example, that makes a beginner think that he knows the whole of a science, that there is nothing more to learn about it because he can recite a few of its results. It is difficult to see what objection can be urged against sound preparation of any kind. Why is it that the professors of languages and of mathematics wish that their students should have some preparation in those subjects, even though the preparation is sometimes bad? It is because languages and mathematics are well taught in good schools, and on the beginning there made, higher work can be done in college. The same is true in physics. That subject has now been carried to a point where it is effectively taught in good secondary schools; and college professors are, I believe, satisfied that it is a wise arrangement by which physics is placed within the reach of young students. Let us therefore urge that several sciences be included in the curriculum of the better secondary schools, and be accepted in the requirements for admission to college, so that those whose inclinations are scientific shall have as good an opportunity in subjects that attract them during their school days as those whose preference is for language and history; and this brings me to my third point, viz, that, if the scientific student comes to college well taught in one or more sciences, we are sure that many students who never come to college have also had opportunity of studying well taught elementary science, and that is a good thing. Indeed, it is so good a thing that it is my chief reason for desiring an opportunity for scientific preparation for those fewer students who do go to college. This may not be properly part of an answer to the question we are here considering, but, inasmuch as it is very generally agreed that the work of students who go to college must on the whole conform to the school curriculum that is prepared primarily for the much larger number of students who do not go to college, it must be admitted that all parts of this problem are so intimately combined that no one part can be determined without due consideration of the others.

My fourth point touches the particular kind of scientific preparation that would be profitable for my students in physical geography. It would be entirely agreeable to me to find newcoming students already well prepared in the elements of physical geography. For then, if they desired farther study of the subject, they could soon go on in college with the physiographic study of the United States, and afterward with the study of Europe, and so on. But it must be avowed that my chief reason for wishing that some students should come to college with a sound knowledge of elementary physical geography is already presented under my third heading; viz, that many others than the few who go to college would then have occasion to learn something substantial about a subject that they will be glad to understand a little as they grow older and see more of the world. Certainly we have no intention of requiring elementary physical geography of all comers, nor even of those who wish to take up the subject in college. We shall continue to offer a physiographic course to beginners. If any one scientific subject should be required, physics seems to me on the whole to have greater claims to that position than anything else.

It would seem sometimes that a question of the kind we are now considering obscures educational problems instead of clearing them. In this case, for example, it is implied that substance and not quality, that knowledge of fact instead of capacity for work, is desired by college teachers. For my part, capacity for work is much to be preferred. I had much rather have a student who had really learned how to study Latin and Greek than one who had shiftlessly "studied" physical geography from a poor textbook under an incompetent teacher; but, if he has earnestly studied physical geography in text, laboratory and field under an inspiring teacher, so much the better. So we go back to the beginning. What I want a scientific student to know is how to work, specially to see, to record and to think.

**Prof. I. P. Bishop**—That the subject of physics is better taught than some others is because of the efforts of this organization to outline clearly the amount of matter to be taught and the general manner of teaching it. One effort of this symposium should be to ascertain whether biologic requirements have been as sharply defined as those in physics. If the college will state definitely and in detail what it wishes, I believe the secondary schools will bring their work up to the required point.

**Friday evening**

## THE SCIENTIFIC BASIS OF MODERN INDUSTRY

**Dean J. B. Johnson**—When the anthropoid creatures, which we are now content to regard as our primitive ancestors, became so highly developed intellectually and manually as to provide for themselves tools of defense and offense, we may well say that then and there they became man, whatever their size, shape, form, or habits of life. Man is the only tool-making and tool-using animal. And throughout all history material and intellectual supremacy has always accompanied the people who devised the most efficient tools. But till James Watt so greatly improved the steam engine in the last quarter of the 18th century, nearly all the power employed in the world to that time had been animal power, and a very large proportion of this was man power. For untold centuries man was but a hewer of wood and drawer of water; a slave and a drudge; a creature to be used, and used up, when friendly and capable, but to be slain or allowed to die of neglect without compunction when unfriendly or incompetent. With the advent of steam as a motive power, in which one ton of coal will do as much work as a man can do in eight years, man ceased to be primarily a motive power and became a director of such power. The laboring man now very largely ceased to be a mere muscular brute and became a reasoning and inventive director of nature's forces to his own great and rapid intellectual development. Since the annual production of coal in the United States is now 240,000,000 tons, and this is very largely consumed in the production of steam power, we may say that the power thus created in the United States every year is as much as the utmost power which all the men in this country could develop if they were all set at hard labor continuously for 10 hours a day for a century. The improvements which have been effected in this one tool, therefore, have not only lifted the most degrading servitude from mankind, but have multiplied man's powers many hundred-fold. The application of this new power to manufacturing on a large scale, and to land and water transportation in the 19th century, has now so revolutionized the material interests and vocations of the race in all civilized countries as to plunge us headlong into a new world, in which we have not yet found our bearings. Truly, old things are passed away and all things have become new. Is it surprising that there are now so many misfits in the institutions of society, or that there are so many vain attempts to stem the tide of revolution and progress which many persons fear is about to engulf the world? Indeed the problems of adaptation to the ever recurrent and rapidly succeeding new social conditions are by far the greatest which have ever come before the mind of man for solution, and they demand of every intelligent, thinking person, his very best thought and time and strength.

By modern industry, therefore, we mean the entire productive activities of all civilized nations; for in all these man power and horse power have now been almost wholly replaced by steam, water and electric power, and these are being employed in ever larger and larger units. And ever the new adaptations of mechanical means to what have hitherto been purely manual employments come more and more rapidly and in increasing numbers, so that what was done but yesterday by hand only, in scores of employments, is today done by mechanical means, in which the brain only of man finds exercise.

Perhaps it would be as well also to define science, though that would seem to be hardly necessary in an audience composed mainly of the members of an association of science teachers. The word, science, has, however, been so greatly abused of late that it seems necessary often to re-define it. Among the many definitions of this word I will choose one of the simplest, and say that science is organized and correlated knowledge (with emphasis on the knowledge).

Most persons seem to think that a science may consist of organized or systemized anything. Thus astrology, alchemy, palmistry, phrenology were all in turn regarded as sciences, but are so regarded no longer. These all consisted in organized or systemized coincidences, assumptions, and theories, and we are not wanting in many modern systems of belief, quite as fanciful and groundless as these, but which are parading in the garments and adopting the terminology of science. That can not be knowledge which is not true. Science includes, therefore, only what is known to be true. We do not yet speak of the science of evolution, but of the theory of evolution. But, you say, if I am firmly convinced of the truth of the fundamental tenets of what has been called the theory of the evolution of the human race, why may I not speak of the science of evolution? This suggests Pilate's query, "What is truth?" I admit that in nearly all human affairs, so-called truth consists in the highest attainable probability. When one thing is to us more probable than any other alternative we can think of, most persons would say I believe this to be true. This may serve very well as something on which to base an opinion, if we must indulge ourselves in such luxuries, but it hardly answers the demands of science.

Again, we must distinguish between qualitative and quantitative truth, or science. To say that all matter is mutually attractive is to state a truth, and a scientific truth, but it is a truth we could do nothing with. It is qualitative only. But to say that all bodies attract each other with a force which varies directly as their masses and inversely as the squares of the distances between their centers of gravity, is to state a quantitative truth which can be used as a tool of investigation and analysis. This is the law of gravity which Newton discovered. By sitting under a tree and noting the fall of the apple, a hoary myth which we must now treat with the deference due to its age, Newton might have concluded that there existed a force of attraction of the earth for the apple which the strength of the stem was no longer able to resist; and, while this force might be called gravity, the conclusion would not establish a law in accordance with which gravity always acts. But it was the law of gravity which Newton conceived, and which he proved to be true by showing that it and it alone could explain the revolution of the moon about the earth.

On the other hand, scientists are constantly challenged by their literary friends to explain the essence of things as well as the laws in accordance with which the essence manifests itself. Thus they say, What is this force of gravity you talk so earnestly about? What is the medium known as the impalpable ether which pervades all space and which transmits this light and heat without absorbing it? What is the mysterious life principle which causes every plant and animal form to reproduce its kind with such marvelous exactness, times without number? And finally what is the mind itself and where does it reside? From whence came it and where is it to go? These and an unending series of like questions we can not answer, but must we hence admit that there is no science of these things? By no means. While we freely admit our ignorance as to the essence, we boldly proclaim our knowledge of the laws of being and of the manifestation of these secret substantial and spiritual forces. And this is quite enough to know, for most practical purposes. So rapidly as the knowledge of a subject can be generalized into laws, therefore, it becomes scientific, even though there remain whole realms of unknown and undiscovered truth still enshrouding the same subject-matter.

This new knowledge is now coming to us with marvelous rapidity and from sources which increase in number in a geometric ratio. This scientific knowledge has been turned also to such practical account in a thousand ways, and miraculous marvels follow each other in such rapid succession that the average man finds himself dazed and his reason almost dethroned by daily observing the accomplishment of what but yesterday he had thought impossible. He is like Alice in Wonderland, quite ready to believe any improbable thing, if it only wear the garments of science. In this way only can we account for the extreme credulity, not to say gullibility, of this the greatest scientific age the world has known. To the average citizen all things are possible, and only await the coming of the scientific magician to discover the trick by which the thing may be done. The very language employed in describing the latest fake, if it be only an unknown tongue, will be accepted and adopted as properly accompanying the hitherto unknown forces or laws. In fact, the greater the fraud, and the more mystifying the language, the easier it is to deceive the wary capitalist. From these facts we should conclude that the greater the possibilities of a given agency, the greater the necessity to determine its limitations. But the determination of the limitations of a force, or medium, or style of mechanism, demands the highest knowledge of both the related sciences and of the mechanical arts involved. There are, however, certain generic truths which have been established, that serve to define these natural limitations in many cases. For instance, the discovery of the laws of the conservation of energy and of its transformation into heat and back again, serves at once as a royal road to intelligent designing and as a great Chinese wall of limitation about a host of mechanical problems which formerly were considered unlimited. In accordance with this law, energy can not be created; it can only be transformed; and hence, any mechanism which promises to give back to us more energy than we feed into it, is known in advance to be a delusion and snare, and no scientific man would care even to try an experiment with such an appliance. While the scientific method is that of experimental verification, there are some experiments which may not even be tried.

With this review of the present scientific status, let us examine its bearings on the field of modern industry. Here, on the threshhold of the world's workshops, we are struck at once with the magic transformations which have been effected in the methods of production. The skilful mechanic, who with great manual dexterity and with a complete knowledge of his art, fashioned a product from the raw material to the finished state, is no more. His like is no longer found outside of Asia. These workers who entirely made up the gilds of former centuries, and who were the pride and glory of Europe in the renaissance, were first reduced to the performance of single manual operations, the complete product being then the work of many hands, and finally, with the introduction of the automatic and labor-saving machinery of today, they have become mere overseers and tenders of such machinery. As we walk through any great modern factory, therefore, we see not manual workers, but machine attendants. But let us not make the very common mistake of supposing these men and women, or boys and girls, to be mere automatons, or animated attachments to the machines they operate. This is the mistake our literary and clerical friends nearly always make. They deplore the age of steam, wind, water, and electricity, and of labor-saving and automatic machinery, and sigh for the good old days when the blacksmith was the only worker in iron; when the wheelwright and the cabinet-maker did all the work in wood; when the shoemaker and the saddler were the workers in leather; and when their grandmothers had added to their other labors the spinning, weaving and making up by hand of all the family wardrobe. These workmen, by laboring from 12 to 16 hours a day, at small wages, managed to earn only enough to provide the bare necessities of life. With bodies worn out with hard labor they came home to rest, like beasts of burden, or resorted to the alehouses to stimulate their weary frames, and so were often transformed into beasts of prey. This exhaustive, slavish toil was deadening to all intellectual life, and it has always greatly handicapped the most aspiring and enlightened souls. But the steam engine and multiple production have changed all this. Not only has the slavish muscular toil been lifted from off our industrial workers, but the wearing and anxious care formerly placed on all such workers in order that they might bring their work up to the requisite standard of exactness, has also been taken over by mechanisms which not only never tire, but which will turn out a million pieces exactly alike. The attendant on such a mechanism, charged only with keeping it in order and well supplied with raw material, has time and opportunity, yes, and the necessary stimulus, to engage in profitable study and invention. The very complexity and the marvelous ingenuity displayed in the machine itself are a perpetual challenge to the operator to comprehend its construction and to improve its accuracy or its output. In place of a more or less degrading physical toil, we now have for these workers a most wholesome combination of physical and mental exercise, which is peculiarly conducive to mental self-improvement in the workshops and also when the day's work is over. The shop conditions were in fact never so favorable to mental effort out of hours as they are today, and the industrial worker was never before so well provided with self-helps. Through our correspondence schools, our periodicals and our public libraries, it is entirely within the reach of all such workers today to obtain a very good scientific, technical, or literary education, and, if they do not choose to avail themselves of such opportunities, they should not for that become objects of a misplaced sentimental commiseration.

But you ask, how has this wonderful industrial revolution been wrought? How comes it that the 19th century marks a far greater industrial progress than all the untold previous centuries combined? By what newly discovered species of magic has the world been so transformed that our revolutionary fathers would not recognize the planet, if they were allowed to revisit it, but would insist they had been transported to some other celestial sphere? There can be but one answer to these questions. The industrial revolution is but one of the many fruits of the scientific progress of the century. The sciences here involved, also, are those relating to inanimate matter. Mathematics, physics, chemistry, mechanics, geology, mineralogy, metallurgy, these in their multitudinous ramifications have, in their applications to the arts, transformed the world. While chance, or accident, or a blind empiricism has often led to important discoveries and inventions, the successful development of industries based on these is always a matter of the scientific application of means to ends. As a rule, however, the scientific laws and principles have resulted from long and patient scientific research, on the part of pure scientists, and the industrial utilization of these has been gradually developed by a class of men whose peculiar business it is to bring the materials and forces of nature into the service of man. These men are known as civil, mechanical, electric, mining, and chemical engineers. The discoveries of our pure scientists, followed up by the inventions of mechanics and engineers, have together wrought these wonderful marvels. And, as the prevalence of science teaching has brought a progress of science which is ever at a swifter pace, so the now widespread technical instruction in this country is bringing our industrial progress along by leaps and bounds. The cheap and quick transportation of goods, by both land and water, has now made of the whole world a common market place. This makes competition universal and the most economic production a necessity to continuance in business. But the greatest economy of production in any line is only attainable by the most scientific methods. The prevention of wastes, the utilization of by-products, the saving of labor, the increase of the output, the perfection of workmanship, the purity of the product, are scientific and engineering questions which find their most successful solution in that country in which is to be found the greatest number of pure and applied scientists. Scientific and technical education is today the foundation of all material prosperity. The more extended and thorough such education is, given to the youth of this generation, the more prosperous will be the generation to come. Bismarck saw this clearly when he said, "Wer die Schule hat, hat die Zukunft." Germany has been acting on this policy for the last 30 years, and her recent marvelous industrial development, without either foreign dependencies or natural resources, has been made possible only by her vast system of scientific, technical, trade and commercial schools. While the German technical colleges have hitherto ranked decidedly below the universities in privilege and in public esteem, a year ago, at the centennial anniversary of the great technical school at Charlottenburg, Berlin, the Kaiser proclaimed that hereafter the technical colleges of Prussia should rank equal to the universities, and would be allowed to grant appropriate doctor's degrees. This practice is sure to be followed very soon in all the other German states. Thus even in classical Germany applied science has now received a just recognition, and the engineer can now wear the much coveted title of doctor, as well as his university colleagues. Heretofore, while a man might do all his work in the technical school, he had to go to the university to get his degree.

While the new census reports on our manufacturing interests are not yet available, I have been informed that in industries in which chemistry controls the product there is now invested in the United States over $5,000,000,000. The next century will be known as the portland cement age, since nearly all classes of structures will be made of it; and we have increased our manufacture of this, a purely chemical product, in 10 years, from 240,000 to 7,500,000 barrels a year, and we will soon be shipping it to the ends of the earth. Five years ago American portland cement was discriminated against, and men who considered themselves experts in this field openly said we never could compete with Germany in this product; but now the Germans are sending to this country for our newly improved cement-making machinery, the superiority of the American product is everywhere acknowledged, and an American chemist is the highest authority in the world on the subject.

In Milwaukee (Wis.) are two steam engine manufactories which have held in turn the world's records for economy of performance, and one of them has no rival in the world for the largest types of steam machinery. Even in the small inland town of Madison (Wis.) we have two factories, one of labor-saving machine tools and the other of electric machinery, which send their products to all parts of the world. There is no doubt whatever, that, if we live up to our opportunities, we shall become the great manufacturing center for the whole world.

And now a word as to the type of man who is our main reliance in this industrial evolution. It is not so much the pure as it is the applied scientist. The discoveries of the pure scientist are common property the world over. We can avail ourselves of a scientific law discovered in Germany as well as if it had been announced from Harvard or Cornell. But to utilize these laws and discoveries in actual industries requires an applied scientist to be on the ground. It is the engineer, or applied scientist, therefore, to whom we must turn in the progress of our industries; and hence I will now consider what qualities and accomplishments he must possess, in contradistinction from the pure scientist, in order to meet fully the requirements of the position.

To the applied scientist that only is good, or is prized, which can be shown to be capable of serving useful ends. It is his business to select from the pure scientists' store of universal truth such as he can use for particular purposes. The pure scientist is to the applied scientists what Columbus was to the Pilgrim fathers. Columbus was bent on discovering a world, or at least a new way to a practically unknown world, while the Pilgrim fathers came to set up for themselves and their children homes where they would be freed from religious persecution—a purely specific and utilitarian end. And yet the results of this specific utilization of Columbus's discoveries have been so great and fraught with so much good and happiness to the world that we are apt to forget the primary discoverer in our gratitude to the men and women who made so specific use of his great and universal achievement.

Our applied scientist must have free and intelligent access to the great storehouse of established truth. He must be a scientist at secondhand. He must not only follow the progress of science in one field, but in every field in which he undertakes to practise. He must therefore be a constant student. This intimate knowledge pertains not only to the laws, the powers, and the forces of nature, but to materials as well. In fact the amount of scientific knowledge required of him to answer to the description we are now making is something quite beyond the ordinary notions of adequacy. It is not gained in a four, or five, or six year course in college. The young man who thinks he has finished his theoretic studies when he has left college can not be included in this category. This breadth of information even the pure scientist does not have, for he is of necessity a specialist.

Our applied scientist must know also how to do things. This is the knowledge the mechanic has. In learning his trade, he has learned the fruits of the world's experience in doing things; learned to do a specific class of things in the best possible way. So, before our applied scientist can decide what is to be done or what is the best way to do it, he must have a large knowledge of mechanical methods. This knowledge the pure scientist does not possess.

Again, he must know what needs to be done. To know this, he must be a man of affairs. He must be acquainted with the ways of commerce and trade, both at home and abroad; must foresee the needs of the immediate future; must know the difficulties and hindrances of present methods before he can determine whether or not it is worth his while to invent new ones. In fact, he must know as much as possible about how the world now does its work, if he is to facilitate matters. This kind of knowledge also the pure scientist does not possess.

Here are three fields of knowledge, therefore, with which the applied scientist must be familiar. He must have a knowledge of a wide range of scientific truth, must understand mechanical methods, and he must know the ways of business and of the industrial world.

But what else must our applied scientist have and be? He must have largely developed in him that *sine qua non* in the profitable solution of all new problems—invention. This seems to be one of nature's gifts. It can be cultivated, however. If from early youth one forms the habit of thinking up new ways of doing things, seeking perhaps for those extremities which necessitate invention, preferring to work with poor tools or none at all in order to see what can be done in some new and untried way, tinkering up toys or making new ones; in these and in a thousand other ways a boy may foster and develop the inventive faculty. It is this faculty which suggests the various possible ways of accomplishing a given thing. From his knowledge of affairs our applied scientist sees what needs to be done. His invention suggests a hundred ways to do it. It unconsciously runs to and fro throughout his mental storehouse of acquired facts, both of science and method, and brings to his attention all the possible ways of accomplishing the result. The reason sits in judgment on this troop of suggestions the fertile invention has marshaled, and selects the one which will best accomplish the end in view, when all things are considered.

Thus, we see, our applied scientist is at once a student of science, a mechanic, a man of affairs, and an inventor combined in one. Nothing short of this will fill the bill. Being a scientist only, he knows not what to do or how to do it. Being a mechanic only, he knows particular ways of doing a given series of things, and he is sure to give you of his little store, whether it serves the purpose or not. Being an executive man, he sees what ought to be remedied, but knows not what to put in its place or how to accomplish any desired end. He probably gets a "practical man" to come and do something, but the chances are very much against this something being the best thing, or the one thing which should have been done. Being an inventor, without the knowledge of either the scientist or the business man, is indeed a misfortune. Our patent laws are a curse to this class of martyrs. A very large proportion of the patents applied for are inoperative from the transgression of fundamental laws, and of the operative ones, perhaps $\frac{9}{10}$ are worthless from there being no demand for the device. Such men waste their lives and their fortunes and that of their credulous friends in their lifelong labor of inventing worthless appliances for doing useless things. They are a burden to their families and to society; for somebody must support them in their profitless and expensive gropings in the dark.

To fit a man for this high calling our technical schools are established. They put a young man in the way of becoming what we have here described. He there learns the elements of a series of sciences and their applications, which it is absolutely necessary for him to know. If this training be preceded or accompanied by a considerable amount of laboratory and shop practice, such as is now given in all our leading engineering schools, and if he also spends his vacations at such work, he learns something of the practical applications of scientific knowledge and of the mechanic's art. Supplementing this with a knowledge of the business world and of men, cultivating a pleasing address but schooling himself to the strictest honesty of motive and act, both with himself and toward others, he becomes favorably known. If, in addition to these, he remains a constant student, and possesses a sufficient amount of invention, he should ultimately become the applied scientist *par excellence;* such a man could safely be consulted in the solution of new problems, and this is the special field of the applied scientist. The duplication or copying of old methods or appliances is the work of the mechanic. The solution of a new problem by the ignorant inventor will bring a long and expensive line of failures, and, if success is reached, it is a sort of happy accident. But our applied scientist should be able to find the successful solution, if there be one, and know before he embodies his ideas in wood or metal or stone that his project will be a success. The mechanic or the inventor must first build and then operate before knowing. The man who makes the scientific application of matter and force to particular needs his exclusive business and profession should know even before trying whether or not his method or device will perform its work. But he is not only called on to make a mechanical success, it must be economic success. If it does not pay, it is still a failure. He must foresee all ordinary mechanical and industrial contingencies before he becomes a safe adviser. With such men to lead, our industrial progress is marvelous. For such men the world has infinite needs, and they can command inexhaustible capital. But, alas! we have not enough such men. Too few men who can at once see a new thing to be done, devise the best possible solution of the problem, present it to the world by convincing arguments, and carry the project to a successful and profitable issue. These are large men indeed. We have hordes of smaller men who can execute projects when once devised, but few who can safely be trusted to devise original solutions to new and untried problems. Success is usually attained after a long line of failures. In fact, it is commonly taken for granted that this must be so. But I believe the day is approaching when even initial failures will be regarded as a professional disgrace, and when we shall have many men whose business it will be to solve new problems in the applications of science with as much certainty of success as if they were problems in mathematics.

When we see what miracles have been accomplished in a single century of scientific applications, largely by a system of blind experimenting and repeated failures or of only partial successes; how we have imitated the great motor of the solar system and remade the world through the agency of heat; how we have obliterated time and space on this little earth and made our antipodes our neighbors; how we have brought near the far-off desert and made it to blossom and bear fruit and so have doubled the size of the habitable world; how "the continuous woods where rolled the Oregon, and heard no sound, save his own dashings," now teems with busy life and resounds to the hum of wheels and the joyous cries of happy children; how the thought, inspiration, discovery, or learning of one is multiplied a millionfold by the press and at once becomes the common property of the world; how the hours of labor are shortened so that all mankind may enjoy sufficient leisure to become learned and cultured if they will; how the comforts of life, which formerly could be enjoyed only by kings and princes, are now available to every industrious citizen; how the causes and sources of disease have been discovered and largely eradicated so that sickness is today almost a crime; when we ponder these marvelous achievements of one short century, mostly by a crude empiricism in applying the discoveries of science, what may we not hope for from the endless future with an intelligent direction given to the labors of those who seek to garner the fruits of all science and not only to know the law, but to control its operation, to harness the very laws of nature to the car of human progress?

Such are the achievements of pure and of applied science in the past, their opportunities in the present, and their responsibilities for the future of industry and commerce. The men who give their lives to the promotion and the application of these agencies are genuine benefactors. They are remaking a world. And, while material progress and prosperity are not the highest good, they bring the conditions which make the higher life possible. You can not develop a man spiritually till he is supplied with the comforts of life and has leisure in which to cultivate the spiritual graces. Thus the most effective missionaries ever sent out from the civilized to the barbarous are the civil engineers. These bring about ameliorating physical conditions, the ultimate consequences of which can not be foretold. They certainly are not altogether physical and material. They are the foundation on which may be built great social developments and spiritual evolutions. Furthermore, the very life of modern industry itself finds its sustenance only in the continual adaptation of new scientific truths in ever new and improved processes and mechanisms. To fall behind in these ever new adaptations is to invite certain inanition and final industrial death. The race is, and will hereafter ever be, to the most scientifically competent and to the most ingenious adapter of scientific knowledge to human needs. Let us also not be afraid of too much material prosperity; we are learning the generous uses of wealth. Wealth is more and more being turned into the channels of popular scientific and industrial education, and this education in turn leads legitimately to greater wealth and also to a greater interest in the high things of this life and to lessening interest in the selfish, and sensuous, and fashionable, and frivolous, and idle amusements of life. In fact, this education in the physical realities of life is the only form of education which will win the interest of the man of business and of affairs as against the counter attractions of money-making and money-spending. When the passion for yachting and horse racing has been supplanted by a passion for developing the resources of nature, and for discovering new truth and applying it to the ever increasing needs of modern society; when the love of personal display and the desire to excel one's neighbors in a vulgar show of wealth have been supplanted by a love of the true and beautiful in nature, which leads of necessity to a higher appreciation of the true and beautiful in life; when, in short, the lower, narrower and more selfish interests of the wealthy class have been replaced by those higher and more altruistic interests which come only with a broader education along lines which appeal to their natures and their tastes, then and only then, will wealth become a fruitful means to righteous ends. In such hands there can not be too much wealth. In that day it may be hoped there will be no idle rich, and that wealth will be used and not abused. In that day a thousand experiments may be tried in the search for new truth, or for new adaptations of established principles, which now remain as dreams and possibilities only in the minds of our pure and applied scientists. It is only by the concentration of great wealth in the hands of individuals that it may be turned into the channels of scientific benefaction and of profitable discovery where the cost of the investigations is great and also the outcome uncertain. By encouraging in every way, therefore, a general diffusion of knowledge of pure and applied science, we may hope not only to bring to our people a vast increase of wealth, but may we not hope that this wealth will then lead mainly to lives devoted to higher purposes, which will lead in turn to a greater dissemination of sweetness and light, and love, and benefaction, and happiness, and truth, and righteousness? Of these things there can never be a surplus.

**Prof. R. H. Thurston**—The citizen, his schools, his industries, his life, is a sequence which primarily interests us all, not simply in the capacity of teacher, of organizer of schools, or administrator of the system of public education and training of citizens for the future and for life, but—and so far as it is a matter of personal concern, perhaps mainly—through our vital concern in our own lives, in our children's futures and in the coming century in its influence over the lives of our nearest and dearest. Every thoughtful man perceives that, as the development of modern civilization progresses, the individual becomes more and more controlled and confined by his environment, and the necessity of early preparation for fitting himself to that environment and taking advantage of every change marking that evolution becomes more serious, more vitally imperative. Our parents might roam the continent, and somewhere each might find an environment within which it was possible to make himself safe without being compelled to fit himself to the crowd, to all the complexities of a life which is always growing more complex and intimidating.

This adaption can not, at this stage of the evolution of our industrial system and of a working life such as practically all men and many women must take up, be secured by instinct; it must come of a deliberate provision of education and training, beginning with the infant and continuing through the period of youth and, with certain classes, beyond adolescence into the stage of maturity. With advancing complexity of civilization, instinct, hereditary memory, continually loses its efficiency as a guide and protector of the individual life; education and training, the wisdom of age reduced to formal expression and of experience stored in available form, become more and more vitally essential. This means that the ability of the parent and of the state to provide such knowledge, in schools, colleges and professional seminaries, is constantly becoming more important in the struggle of the individual for life and for the good things of the world; that the position of the individual in the social scale and among his fellows is steadily exerting a more important and controlling influence; and that heredity must tell increasingly through material success and accumulation of material potential powers. Where, once, a man could make a success in a generation, starting from the lowest level, and where, of late, two and three generations are more often needed, soon highest success in great achievements can be expected ordinarily to follow only on foundation building which has occupied ancestors of several generations, steadily and persistently adhering to the fundamental elements of progress throughout. This, again, means the gradual progression of social stratification in a more and more distinct manner—a result which, however unsatisfying to our democratic inclinations, must probably be accepted as inevitable. We shall probably enjoy, however, the compensating fact that the lower strata will continually find higher levels assigned them, so far as their position is determined by ability or good fortune. All honest endeavor will be better rewarded, and the extent of reward will include a wider range, with extension of that range mainly in the upward direction.

Such conclusions can hardly fail to follow any serious study of the progress of modern life, specially of modern industries and their resultant developments, in any civilized country. The correctness of these conclusions is shown clearly by the statistical, as well as by the more general, method of historical investigation. It is this which has brought about the discovery that, on the whole, such progress tends to reduce, relatively, the numbers of the very rich and of the very poor, increasing by similar proportion the relative numbers of the intermediate, well-to-do class, while all the time raising the standard of living of the latter. It is only necessary for any person of middle age to look back to the days of his childhood to perceive this last fact distinctly; and a perusal of the pages of Buckle or Lecky, or the reading of the general literature of the last century, will show how rapid this change, moral and intellectual as well as material, has been since the crystallization into form of the contemporary industrial method and since the entrance of any people into the characteristic form of modern life. Read, for example, if more detail is desired, Wells's *Recent economic changes* as a supplement to portions of Draper's *Intellectual development of Europe.*

The indications of a coming change may be seen as far back as the beginning of the 17th century, when that wonderful renaissance of scientific research began which has continued, uninterruptedly, to our time; but the progress then initiated became sensible and its movement became a distinct acceleration, of rapidly increasing rate, only in the 18th century, after inventors, who in ancient times would have been made demigods, gave their fellows the machinery of the textile industries, of the iron and steel manufacturers, and, above all, that Archimedean lever which now moves the world—the steam engine. With the birth of the 19th century progress assumed aspects previously unknown, and change became so rapid as to cause disasters to many, while promoting the best and highest interests of the world as a whole. The "trend of progress" not only became marked, but its curve took on increments of gain which were themselves subject to acceleration. The "curves of progress" rapidly, and more and more sharply, rise with the growth of the century and, as yet, with no indication of change of law. The 20th century seems likely to illustrate quite as markedly as the 19th this wonderful progress of the great body of the people toward a higher and better life in all its phases.

But there are many other gages than those of the older historian, measuring this progress, and, in our time, the measure generally regarded as the most satisfactory is that of the consumption of iron and steel; since these forms of the most precious of metals are employed, directly and indirectly, in every department of modern life. Its most important industries and most widely spread blessings are absolutely dependent on the use of these metals for their value and fruitfulness. All great industrial operations, whether in textile manufacture, in food production, or in transportation, are dependent on the supply of iron and steel, and the amount produced, *per capita*, thus measures the wealth, the comfort and the general prosperity of a country. During the century, for example, our own country has increased its annual production from an insignificant amount to nearly 15,000,000 tons and from a correspondingly insignificant weight, *per capita*, to nearly 400 pounds for every man, woman and child in the nation, about 1 ton to the family. The rate of consumption is still growing, that of production is increasing in still higher ratio, and we are beginning to supply the markets of the world with manufactured iron and steel.

But there is still another measure of progress which is, in a sense, better than even iron and steel production and consumption. Though not more accurate, probably—I doubt if anything could be more accurate—it is more satisfactory in that it shows us a more interesting aspect of progress, a more important phase of evolution, than the material gage. This is the progress of higher education, as supplementary to the common school education of earlier decades, the latter of which lies at the bottom of all intellectual advance in our country. The common school system and the political and individual freedom of the American citizen, together, have promoted most effectively the march of invention and the perfection of industrial systems, as well as all other good works in every department of human life. The particularly impressive phase of educational advancement in our own time has been the extraordinary stimulus given higher education, specially in those departments of applied science which have furnished the scientific basis of modern industrial life.

Studying the "trend of national progress",[1] as I have called it, we find that the iron and steel production may be shown by a set of curves of progress, which have their very exact counterparts in the curves which relate the growth of the working power of the world since Watt to the flow of time during the century; and these, in turn, will be found to have a very close relationship to those which exhibit the development of the modern forms of the technical school and the scientific departments of our academies, colleges and universities. All show a low figure for output in the early part of the century, a hardly perceptible growth in the earlier decades, a sensible acceleration toward the middle of the century, rapidly increasing advance, with an increasing *rate* of acceleration, as we enter on the last quarter century, and all exhibit wonderful progress in these later years.[2] Laying down these three curves on "squared paper", a singular correspondence will appear, and there becomes obvious the fact of some common cause. Comparing the series with another graphic presentation, that of the growth of that product of industrial activity which represents permanent wealth, that class of products of manufactures and industry which Mr Mulhall calls "sundries", we find an almost exactly similar trend of the curve of progress as indicated by either line, and, when we farther investigate the subject, we find another set of similar curves representing the gain of the nation in wealth, both aggregate and *per capita*, specially in that portion of accumulating wealth which is secured by the people as wages, both aggregate and

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[1] Thurston, R. H. "Trend of national progress," North American review, Sep. 1895.

[2] ——— "American competition." London engineering, Mar. 30, 1900.

*per capita.*[1] All these simple, yet most expressive and instructive pictures of the progress of the nation are, each in its way, expressions of the progress of the civilized world; for all civilized nations furnish us such illustrations.

During the 19th century, the inventor has increased the power utilized from the forces of nature, from perhaps 5,000,000 horse power, at the time of Watt, to, in this country alone, 25,000,000 at the middle of the century, to 70,000,000 in 1875 and to about 150,000,000 at the end of the century. Wealth increased slowly in the early half of the century, doubled several times between 1850 and 1875, and then commenced, with the latter date, that wonderful progress which we have since observed, amounting, now, with the close of the century, to about $25,000,000,000 in houses, $15,000,000,000 in lands, an equal amount in railroads, and some $5,000,000,000 in factories and an equal sum in cattle; while the "sundries" account, measuring all the characteristic comforts of civilization, has risen from $2,000,000,000 or $3,000,000,000 in 1850 to twice that sum in 1875 and to $30,000,000,000 in 1900. Wages have risen from about $300,000,000 aggregate in 1850, to $750,000,000 in 1875, to above $5,000,000,000 in 1900; the operatives receiving, each, on the average, not above $250 in 1850 and $350 in 1875 but reaching $500 in 1890 and nearly $700 today—the highest compensation in any country in the world and in all history. Of this, also, every dollar, and every day's labor, buys more today than ever before in the history of civilization. The 20th century opens with this marvelous and optimistic outlook and, if no wars, pestilences or other social catastrophes, break the curve, its history is likely to be as marvelous from the point of view of the generation living at the dawn of the next century; indeed vastly more marvelous than the retrospect which we enjoy at the close of the 19th century.

Could similar statistics be secured, and pictured in curves of progress illustrating the advance effected in educating the people, very similar and no less surprising and encouraging conclusions would be reached, both regarding the past and respect-ing the future. Today, 16 of the leading colleges of the United States report about 40,000 students registered, and their annual output is about 8000 men; of whom probably 1000 are in the departments of engineering alone, and a still larger proportion in the more ancient departments of the so-called learned professions. To the latter, however, the former are now to be added, since their requirements for admission are more exacting and their courses of instruction are more crowded, are generally more mathematical and are fuller of branches demanding brain and work. The century has seen enormous growth of collegiate work, specially in the departments of applied science.

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[1] Thurston, R. H. "Trend of national progress." North American review, Sep. 1895.

The compulsion which has brought about this immense development of higher education has consisted, we must conclude, of three main elements: 1) that ability attained through increased and more widely and uniformly distributed wealth, on the part of the people, to secure higher education, which always marks such progress as we have traced in our material evolution; 2) that constantly growing demand for more generally learned men in the professions, including now the constructive professions; 3) that constantly growing and increasingly intense demand, in all industrial vocations, for a scientific basis for all industries and for highly trained, for learned men in all great enterprises and in every system of industrial production. But all these elements of the aggregate compulsion rise out of and accompany the evolution of the modern industrial system; which, in turn, is based on that progress in civilization through the work of the inventor, the mechanic and the man of science which is giving us such marvelous accumulations of material wealth, with all its higher accompaniments in the realms of the sciences, the literatures and the arts, fine, useful and esthetic. This development gives at once the stimulus and the opportunity.

Perhaps the best index of the magnitude and importance of the demand which the country is making on the teachers of science for a basis for industrial development is seen in the growth, during the last half century particularly, of the profession of engineering and in its characteristic changes, in consonance with the alteration which has taken place in the industrial situation in the last generation. At the middle of the century, less than 50 engineers were graduated from the schools of this country each year, and those were mainly, nominally at least, civil engineers, and their principal employment was railroad building. After the close of our civil war, the mining and the mechanical engineer began to find a larger place in the industrial system, and during the next 20 years their numbers became, each, about one third as great as the number of men engaging in civil engineering[1]. Since that time the number of civil engineers has relatively decreased, and the output of mining engineers has been almost stationary; while the number of young men going into the mechanical branch has increased enormously and now considerably exceeds the number in the oldest division. The total output for the country is now about 1000 a year, and the growth and the rate of growth are both continuously increasing. Reckoning from 1870, the total gain in numbers is equal very nearly to the square of the number of years elapsing; which indicates a rate of progress parallel with that shown in the curves of the industries generally and of the wealth of the nation and of the average citizen.

The deduction of most importance in this connection is that the teachers of the country, specially the teachers of science and of technical subjects in applied science, may expect some such law to hold in the immediate future and probably for many years, if not for generations; and they thus find here a measure of the responsibilities devolving on them and of the splendid opportunities coming to them in the evolution of the "complete and perfect education" and of the Utopia that will certainly be realized by our successors, in later generations, if only humanity is permitted to lead the march of the world, unchallenged, as absolutely as have representatives of baser character in times past.

The scientific basis of modern industry must hereafter be supplied by the engineering and trade schools, and the sciences will become more and more completely the foundation of all industries. The generals of the industrial army must be more completely and perfectly educated for their work, and more and more cultured, as they become more essentially leaders of men and sources of power. The preparation of youth for entrance into these constructive vocations and professions must be begun in the preparatory schools, and, consequently and obviously, the prosperity of the nation and its place among nations will ultimately be determined largely by the wisdom, the earnestness, the talent and the conscientiousness of the science teachers in our schools. Men of large views, wise understanding, unselfish and unprejudiced minds are now needed, more than ever before, to guide legislators, administrators, people and pupils; and nowhere are they more to be looked for than among our contemporary science teachers—free from tradition, prejudice and self-interest as is no other class in the community.

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[1] Thurston, R. H. "Technical education in the United States." Trans. Am. soc. mech. eng. 1893.

It is thus that we find all our curves of progress obeying similar laws and following parallel lines throughout the century, promising hereafter similar parallelisms, through the immediate future, at least, and probably through the coming century. The 20th century will, we may hope and expect, illustrate precisely as the 19th has this mutual interdependence of all stimuli and all opportunities. Productivity, wealth, all material and intellectual and spiritual progress will be more and more closely interrelated as time progresses. The revolution, though effecting these wonderful changes in the " wonderful century " as Wallace calls it, just past, has but, in fact, only now begun, and the change thus inaugurated remains to be completed in a future the duration of which we can not yet surmise, much less predict.

Every modern industry has a foundation in applied science. Art has ceased to be empirical, and all arts have become systematic and scientific. Chemistry gives us today a revivified soil, selects for us the most remunerative crop for the location, soil and climate, determines for us the best food for the plant and the most appropriate method of cultivation; entomology teaches us the habits of the useful and the harmful insects, shows us how to save a million dollars in a year, among the fruit trees of western New York, and how to battle with the hosts of the army worm and the locust; botany gives us new edibles and teaches us to cultivate them; mechanical science supplies the agriculturist with his mower and reaper, his binder and threshing machine, his gang drill and steam plow, transports his harvest to a transoceanic market and gives the laborer in New England flour from a mill in the northwest, at lower cost than is made at his own door, minimizing and evening the costs of existence to all the world. The chemist gives us an artificial madder and changes the course of trade in a great staple, benefiting thousands; the physicist provides us with a science of electricity and gives to the engineer control of a form of energy which distributes power from waterfall or steam engine over miles of railway, or to a thousand arc lights, or to an industrial center beyond mountains and valleys, or to widely separated nuclei of manufactures and trade.

The mathematician gives to the astronomer his tools of trade, and the astronomer shows the mariner how to find his way from port to port over thousands of miles of intermediate ocean and to enter the distant harbor without changing his course by a spoke of the steering wheel, as safely at night as in daylight, or in storm as in calm. The ship-builder avails himself of hydraulic science and builds a ship of iron, lighter and vastly stronger than any wooden vessel, reducing wasteful weights, increasing paying cargo and capable of crossing the Atlantic in less than six days. It is driven by engines of 30,000 horse power and boilers sustaining pressures of 10 or 15 atmospheres. The marine engineer is transporting a ton of freight a mile at sea, with the amount of fuel contained in a single half ounce letter. The builder of the best mill or water works engine of today, availing himself of every discovery in the domain of thermodynamics and of all the perfected and scientifically constructed tools of the educated machine-designer, produces a hundred or a thousand horse power with the expenditure of a pound of fuel, or of something above 10 pounds of steam, for each horse power hour; while the builder of the gas engine of equal power claims to have already surpassed this splendid record. The engines of Watt demanded several times as large a fuel supply; and even so late as 1850, when the science of thermodynamics and the methods of experimental science in this field were in their infancy, but about one half as large a return from a stated amount of stored energy in fuel could be obtained by the most successful constructors. It is achievements of science such as these that have given to the world its present wealth, comfort and intellectual powers and privileges; even the spread of acquired knowledge by printed books and every function of communication of ideas now depend for effectiveness on the genius of applied science, as illustrated in the perfecting press and the machinery of the book-making mechanician.

The development of science through research, its extension by cooperation of all investigators with all teachers and its utilization by the technical and industrial vocations and professions are thus among the essentials of modern progress. All workers, in all these departments, must work hand in hand and each with zeal and efficiency, if we are to make the most and best of our opportunities; and the scientific basis of modern industry can only thus be laid down. It may compel a complete revision and reconstruction of our curriculum; but we may be assured that whatever is needed will be found practicable and will ultimately be secured, and any cost in time or labor, or sacrifice in minor matters, will be fully compensated.

The most learned men of our time are, as a rule, not members of the "learned professions", distinctively so called in earlier days, but are found among the teachers of those aristocratic classes and among teachers in all departments of learning, among men of science, philosophers, diplomats and engineers, mathematicians and philologists, jurists and men of achievement, as well as among men of books. The expansion of our colleges is, in these times, mainly on the side of natural science, applied science. All languages and literatures, all mathematics and all ancient forms of learning are now valued both for their disciplinary effect, as of old, and for their helpfulness in the making of a man competent to aid his fellows in the highest degree. As I have often quoted, "it is as easy to go somewhither as to walk around the square" in the acquirement of learning and applied science. Applied gymnastics and ultimate accomplishment of good become the gages of the value of the man, and of his life, in the minds of all who have come completely out of the past into the atmosphere of the contemporary world. Dreams and dreamers are today alike ignored.

Thus it happens that our colleges are so rapidly becoming catholic and universal in their range; and the real test of the desirability of a study therein is now helpfulness to classes of men hitherto unable to secure opportunity for higher learning in their sections of the intellectual world or in their broadening and rising professional requirements. Does any sufficient body of men desire and need this opportunity to acquire learning in this field? This is the real question to be asked and answered by the college, the professional school of the university. We are today becoming as catholic as the Egyptians at Thebes and the Greeks at Alexandria and our curriculums as correctly university programs as were those of their colleges; yet it is mortifying and saddening to recognize the truth that 2000 years have elapsed since a true university was planned and organized. and that only now have successors appeared to those pioneers. Even now such are few in number, incomplete for the times and still subject to obstruction in a multitude of ways. The contemporary Cornellian idea was that of the unknown early Egyptian, of Aristotle, of Descartes, of Milton, of the marquis of Worcester, of many wise men living in the intermediate periods. Of all the nations of our day, only the Germans have systematically followed the Aristotelian idea in its generality and have formally established a national, universal, system of "instruction of any man in any study", as Cornell phrased it; only the French have organized a national university, after the ancient plan, at the capital of the country; and only the United States has a system of primary education aiming at the instruction of all classes and conditions of youth in all the primary studies, universal in its welcome of all the children of all citizens.

France, Germany and the United States thus have, each, an element of a correct system of education of a people for the life and work of a people; but neither has a full, spherical, organization of an educational system which provides for the children of all sorts and conditions of men, offers a training in the scientific bases of all modern industries, gives to all youth their choice of path into the kind of life and work best adapted to the natural talent of each, and affords free access into the learned professions for those capable of entering with promise of success. Our common school system requires supplementing by an equally catholic organization of scientific, manual training, trade and technical schools, such as Germany has provided, and by development, in college and in university, of the whole scientific basis of all the great industries now demanding firm and deep foundations, such as never were required before. Still more, above and beyond the whole university of instruction, is needed provision for extensive research in all departments of sciences, literatures and arts, in which men of genius and talent shall be given leisure and opportunity deliberately and fruitfully to display their powers in the extension of human knowledge and in opening new paths for the teacher, the inventor, the organizer of industries; accumulating learning for transmission downward to all men capable of profitable acquirement and use of the fruits of original research and discovery. The whole completed and symmetrized system is to be mainly developed by extension of the sciences and their applications; for the older learning is already admirably presented in the pioneer institutions of learning of all grades.

A noble beginning has been made; but all our newer departments of education are still more or less dependent and mendicant, and must so remain till the state can be induced to provide fully for them—as fully as for primary and secondary education.

The western states are doing something in this direction, and in some cases in a creditable though still incomplete way. The Miltonian "complete and perfect" education can not be entirely organized, however, till statesmen shall arise capable of appreciating and of inaugurating and liberally sustaining that university which shall comprehend all divisions of the curriculum furnishing Huxley's ladder, leading from the gutter to the research department of the university, for the son and the daughter of every citizen, whether of high or of low degree, if only intellectually capable of climbing it.

While it is obviously a folly to attempt to utilize "a three story education in a one story brain," it will be admitted to be the highest aim of statecraft and social economics to see that every "three story brain" shall have the opportunity to acquire a "three story education" and thus to return to the nation a many-fold premium on the investment. One great mind lost to the world through lack of the highest education which it is capable of utilizing is a more grievous loss than sunken fleets. One Watt, Faraday, Corliss, or Darwin, undeveloped and uneducated to the highest point of vantage, means loss inestimable. One great man at the highest altitude to which he is capable of rising is worth more than any mine; one genius, trained and cultured, outvalues a multitude; one statesman, one industrial commander, one great exploiter of scientific knowledge, counts for an army, for he makes effective an army, saves a country from ruin, raises a nation to previously unimagined hights, confers the comforts of the highest civilization on the people or gives his fellow-men leadership toward hitherto unexplored realms of wisdom, knowledge and opportunity. The grandest financial expenditures by the state are those which develop moral, intellectual and physical forces for the benefit of the nation.

The progress of the century past has been largely due to the fact that every modern industry has come to be underlain, as we have seen, by a scientific foundation; the laws of nature are made the basis of every act of every worker, every operation is carried through a sequence of movements of man or machinery or both, dictated by natural law and human reason, and the construction of mechanism derived wholly through scientific method. Agriculture has a science which is a composite of chemistry, botany and entomology; mining and metallurgy find a foundation in the sciences of chemistry, geology, mineralogy and thermal physics; architecture builds on geology and applied .mechanics and the fine arts; the textile manufacture depends on the sciences underlying the production of cotton, the breeding of sheep and the cultivation of the silkworm; the construction of machinery is a problem in the mathematics of applied mechanics; and the heat engines derive their powers from the forces of nature through application of thermodynamics, physics and chemistry. All civilization depends on the thermodynamic machine for physical power; all races derive their life and energies from agriculture; and spiritual life profits by the wealth of learning, mainly in the domain of science, which the successors of Aristotle have distributed to the world while depending on accumulated wealth for their sustenance meantime. The science of life, the science of wealth, the science of industry are each essential to the perfection of human life. All are parts of one pantology, the perfecting and completing of which is the task of the century. Learning without law is an impossibility, and the sciences of learning are the sole basis both of all industries and all worthy life.

There is no nobler task in this completing and perfecting of the modern education than that of the science teacher, and his labors are becoming daily more fruitful and encouraging and better recognized. When the agricultural departments of the land grant college of the state of New York send out nature study leaflets to 20,000 members of the Farmers reading class, print 250,000 pages, in a single year, of "teachers leaflets," supplies 35,000 copies of each study for the "junior naturalists clubs," teaches 2500 members of home study classes, provides science lectures for 30,000 people, printing an aggregate of 7,000,000 pages in a year, distributing them among those interested in agriculture and kindred studies alone, it can hardly be asserted that the work of the science teacher is not appreciated or that it is not, in extraordinary degree, useful. Yet the work in this one department of industrial activity is but a fraction of that which must ultimately be called for in the maintenance of the scientific basis of the modern industries in all the vocations and professions.

A "complete and perfect" system of education of the people thus provides largest, richest, best returns. What we term technical or professional education is that highest form of preparation for life work in highest fields which constitutes the noblest kind of apprenticeship; and the science teacher's task is an essential element of this preparation of the citizen for the grandest tasks of our time. This means the approximation of our methods and of our intellectual product to the ideals of Aristotle, of Hero of Alexandria, of Leonardo, of Descartes, of Comenius, of Paley, of Bacon, of Milton, of Worcester, of the great French scholars and the great German statesmen of our era, and to the highest and noblest ideals of all our own greatest men, from Washington, Jefferson and Lincoln to Wayland, Walker, Cornell and Andrew D. White. It means the universal completing and perfecting of the citizen's education with due regard to his capacity; so that, as Milton expressed it, he may "perform justly, skilfully and magnanimously, all the offices, both public and private, of peace and war". Today the opportunities, the duties and the victories of peace, rather than war, direct our judgment and our work and involve the useful employment of all arts and sciences, the utilization of all literatures, of every mental and physical talent and of all the available energy of the man. In all this, science must hereafter perform a vastly higher and more fruitful part than ever before; and her duties will become more and more fruitful, ennobling and helpful, to teacher and pupil alike, as the years go by, and as the new century reveals its many and mighty tasks to us all.

**Saturday morning, 29 December**

## SECTION MEETINGS

## Section A. PHYSICS AND CHEMISTRY

### RELATION OF HIGH SCHOOL TO COLLEGE PHYSICS

BY PROF. JOHN S. SHEARER, CORNELL UNIVERSITY

The rapid introduction of physics into high school courses and the demand that the work done there be accepted for entrance to college make the relation between high school and college work of ever increasing importance. In the discussion of the matter we may leave out of account the fact that most high school students do not go to college, as we are here concerned only with those who are preparing for higher work.

Several years ago, while teaching elementary college studies, I was surprised to find that many of the students having the greatest difficulty with the work had evidently had a course in the subject before. Last year, when again giving the same work, I looked into the matter with some care and secured statistics as far as possible concerning previous work in physics. The result was that the average grade of those having had a previous course in preparatory schools was a little over 3% higher than that of students taking the subject for the first time. If those coming from four schools were excluded from the list (nine students), the average of those having had previous work fell considerably below that of the others. While of 35 men who failed in the subject, 19 reported previous work, five had not studied before and 11 gave no answer. I learned later that several of the 11 did not like to admit that they had taken a preparatory course. It would seem from this that in our case at least, the high school course is not as good a preparation for future work as might be desired. It remains to seek the causes which may have led to this result. We can hardly postulate that the men who had had high school work in physics were mentally inferior to the remainder of the class, and the fact that several men who prepared at certain schools stood extremely high indicates that a preparatory course may be of great benefit.

The best indication of the probable causes of failure may be found by careful observation of the students themselves. My own experience leads me to believe that the following are among the principal sources of trouble.

1 Formulas are memorized without any clear understanding of their meaning.

2 Problems are solved by rule of three as a substitute for careful analysis.

3 The student is carefully shielded from any encounter with the real difficulties of the subject.

4 He is allowed to acquire the idea that the entire subject is included in the elementary text he uses, or at any rate in the brain of his teacher.

5 The idea that physics pertains only to the classroom and laboratory and has no connection with actual affairs is too prevalent.

6 The habit of self-reliance in testing things by experiment and by deduction from known laws is not developed.

With regard to the first of these it may be said that there is no method more fatal than crowding the brain with meaningless formulas. We often find men who failed repeatedly in physics who remember more formulas than an experienced teacher ever expects to know. It seems almost impossible to make students believe that their entire time should not be spent in memorizing aggregations of symbols absolutely isolated from any realities. This tendency is doubtless encouraged by a certain type of examinations which can be passed as well by this method in many cases as by a more scientific one. We have found that questions shaped so as to make direct application of formulas inconvenient, together with examinations in which students are allowed to use their textbooks, greatly reduce this tendency.

If the method by which problems are attacked is carefully observed, it will often be found that the educational value of problem work is almost entirely lost. The tendency of nine out of 10 beginners is to solve a problem by pure imitation of a textbook solution having similar wording. Failing in this, that ever present crutch for weak minds, " rule of three ", is impressed into service. Having carefully observed students in all stages of advancement in the subject, I have yet to find a single one habitually solving problems by this method who has been fairly proficient in the subject. The careful analysis of a single problem is worth more than any number of mechanical solutions.

That there are real difficulties in physics no one familiar with the subject will deny. Indeed, it would be hardly worth our while to study or teach it if there were none. Why then should the beginner be lulled into fancied security by artificial simplicity only to be rudely awakened when the work is taken up again? I do not mean that he should be forced into work too difficult for him, or that topics unsuited to his advancement should be presented for discussion, but that the work should be rigid enough to demand at least as much mental effort as corresponding courses in mathematics or classics.

Not infrequently we find those whose thorough study of a very elementary course is an actual handicap for any university work. Two of the most hopeless cases I ever saw were men who had taken a postgraduate course in physics where the work was of a grade inferior to that which many of our best high schools offer. They were firmly imbued with the idea that what they had done covered all of physics worth doing. Their minds were completely fossilized by long plodding in an infinitesimally small field. The student or teacher either young or old who feels that his subject contains nothing new for him has passed the period of usefulness. There is no subject more intimately related to everyday life than physics. The entire universe around us is a great physical laboratory. Every movement is an example of mechanics; the phenomena of sight and hearing, the way our buildings are heated and thousands of other things contain problems yet to be solved. The boundary between the known and the unknown has been slightly modified during the century just closing, yet how little of natural phenomena is in any sense understood at the present time!

The student should also be early taught to depend on his own resources and to trust his own observations. Hours are often spent in trying to find something in a book when an actual test could settle the matter in a few minutes. There is nothing more trying in a laboratory than a student who is never sure whether he has measured correctly or not, or one having no initiative and standing dismayed whenever an unexpected difficulty arises.

My idea of what the high school should strive to do for the student in physics is perhaps apparent from the foregoing. Stated in few words, the aim should be to develop correct methods of thought and study rather than to attempt to overload the mind with disconnected facts. Living cyclopedias are seldom useful either in college or elsewhere. One who does not know some things may be easy to teach, but a man who does not know how to think is a burden to all whom he may encounter. The men we need most are those who can think and do instead of those who remember and repeat words.

No time should be spent in college in unlearning things which are not so. We have far more trouble in attempting to teach Ohm's law to students who have learned that $C=\frac{E}{R}$ than in any other one thing in electricity and magnetism. Rather, the college course should be an unfolding and development of the mind along lines of thought already properly established. The high school should leave the student with a living interest in the physical phenomena which surround him. His thinking powers should be quickened by actual contact with real things and not paralyzed by textbook phrases and obscure formulas. He should not acquire the idea that all of the active world has been formulated in books or that apparently simple laws are unworthy of careful study many times repeated. To one properly trained no physical phenomenon is so simple as to become uninteresting. Above all, there should be a development of ordinary common sense regarding the commonly observed phenomena in everyday life. The aim should be a golden mean between a course so difficult as to lead to discouragement and one so easy as to delude him into the worse condition of mental frivolity.

In work of this kind we must remember that the personality of the teacher is of more importance than any other single factor. A well equipped laboratory and convenient lecture room are to be desired, but teachers having a knowledge both broad and deep and withal a living interest in the development of their subject are indispensable. We hear a great deal about methods, the relative value of classroom and laboratory work—questions of great importance of course; but I still insist that a knowledge on the part of the teacher much deeper and broader than the student can attain at his stage of advancement is the essential thing. Better teachers are required for those totally unfamiliar with any subject than those who are well started in the right way. And this is preeminently true of physics. I have no hesitation in saying that the realization of the highest ideals in the teaching of high school physics demands better preparation and greater resources on the part of the teacher than are required in elementary college work.

Do not think that I in any way reflect on the efforts of the teachers in preparatory schools. No one appreciates more fully their difficulties; and I only wish that their efforts may be directed from the right standpoint and toward the right end. Neither do I forget that the high school pupil is less mature than those who begin work in college; but I firmly believe that mental habits are often firmly acquired early in school life. The proper development of the thinking mechanism of an individual is a greater task than forcing the memory to retain physical constants or abstract formulas.

When work of this kind is done in all our high schools, the cry that the mental training of science is inferior to that of mathematics and classics will become an echo of the past. Then there will be no trouble in securing recognition of work for entrance to our colleges and universities.

That such task is a severe one I certainly would not deny. Yet I feel that it can be done, if to the skill of the teacher you bring the living enthusiasm of the investigator; and such an accomplishment affords one of the highest ideals for the teacher of science.

**Prof. O. H. Robinson**—The work done in physics in the preparatory courses is not as a rule such as can be used to advantage by college professors. We can not begin where the high school and academy teachers leave off. We can not build advantageously on the foundation which they lay. The trouble results from no fault of theirs, but from the nature of the course which they have to give. In almost all cases their classes are made up of a few students who intend to take a college course and many students who have no such intention. They are obliged to teach these two classes of students together. What is wanted is a general, and somewhat popular, course covering all the subjects usually classified under the head of physics. This is given; for it is the only opportunity the majority of the students will ever have to study these subjects. Now, no one doubts that this work is well done. The teachers are scholarly and conscientious. They do excellent work. Wherever time enough is given to them the students acquire a good general knowledge of the subjects.

But when all this is said the fact remains that the college preparatory element in such classes does not get a good preparation for college work. This results, in my judgment, mainly from two causes.

First, having gone over the whole course before entering college the novelty of the subject is gone. A student of mature years, or a professional student, has the patience to dig deeper into subjects of which he has a general knowledge; but youths in a non-professional course are not so. They need the stimulus of novelty. Moreover, if they have done their preparatory work well they are quite sure to think that they already know what there is in a course in physics. This is very natural. Their teachers have, very properly, recognized their merit in the study of every subject; and what more can be done?

In this attitude of mind a student enters on his college course with the intention of doing very little work in physics. Has he not done that work already? Half an hour a day should suffice to look over the lessons, and refresh his memory. He divides his study hours among the subjects in hand on that basis. Perhaps he takes on himself an extra course of something, assuming that he has time to spare. In a fortnight he finds that the study of physics is not what he thought it was. His professor is not satisfied with mere descriptions of phenomena and statements of laws. He is expected as far as possible to prove the laws as he goes, and reduce them to proper algebraic formulas. He must solve a lot of problems, problems which require the use of his formulas, and of trigonometry and analytic geometry. His half hour will not suffice. In a month's time he is behind his class, and discouraged. I am giving no fancy sketch, or mere theory of the case. I am presenting a practical difficulty which I have met again and again during a long experience. Students in mechanics come to me in great trouble in the middle of their first term—fairly good students too. After all their study of physics they don't see why they have such hard work to get their lessons. The author does not state things clearly. The teacher is too exacting. I see the difficulty at once. On inquiry they own up; they have not thought it necessary to put time enough on the work. They have got behind; and every teacher knows what that means in a subject like mechanics. It means for them a radical change of habits, or failure. What is the result? With no novelty to interest them, and not intending to pursue the study professionally, they determine to get through the term as best they can. At all events they act as if they had so determined. Now my conviction is that the majority of students so prepared would have been better off at the end of the term if they had entered on the college work without preparation. I have every year in the same class with them those who have so entered, and the comparison is easily made. What I have said of the first term may be said with slight modifications of subsequent terms.

A second reason why, speaking generally, the high school student does not get, and can not get, a good preparation for college work in physics arises from his lack of mathematical equipment. To a certain extent this underlies also what has already been said. It is practically the primary reason why preparatory students can not form habits of study in physics which they can carry with them into college work. They are so handicapped that even the best teachers must fail to develop in them such habits. Preparatory courses do not as a rule contain the mathematics necessary to study from the very beginning the subjects contained under the term physics as a student preparing for the liberal study of a college course should study them. A student who begins them with his algebra, geometry, trigonometry, and analytic geometry all well in hand can form the right habits at the outset. He has no disappointments, no bad habit to overcome as he progresses. His interest is sustained throughout by the novelty of the subjects as he takes them up. He does not get discouraged but pursues his course steadily and successfully to the end.

What is the remedy for this state of things? The answer requires more time than can be given to it today. Clearly the high school and academy teachers are not at fault; and just as clearly their students are not at fault. Some one else may find a solution of the difficulty; but with my present knowledge of the subject, acquired by long experience, it seems to me unwise for students who intend to take a college course in physics to enter on that branch of study before they have the mathematical preparation for it.

## MANUAL TRAINING OF CHEMISTRY

### BY PROF. WILLIAM E. BENNETT, ROCHESTER HIGH SCHOOL

From the turmoil of discussion and the research which in these days distinguish the educational world, a new conception of the aim of education is evolving. This comes slowly, with much labor and many mistakes, but the result is to be a system which shall develop full-rounded character—manhood and womanhood capable of thinking but also capable of doing.

The school of past years, whether primary grade or university, aimed to develop mainly the intellectual side of the pupil; but within recent years the business of the world has demanded, and today it demands trained specialists; and, as a result of this demand, much attention is paid to the education of the body—the training of the senses and muscles.

To be sure, much specialization is intellectual, but the utilitarian world pays its most immediate and richest material rewards to the doer rather than the thinker, and, as a result, by far the most specialization is a training of the physical powers largely.

From each of these extremes we should take the best. The educator is beginning to realize that neither mind nor body alone is to be developed, the one at the expense of the other, but that the fullest harmonious development of both must be sought, and that the activities of the two must be coordinated to the largest possible extent by that educational plan which is justly to claim preeminence in the development of well rounded life.

It is not the purpose of this short paper to state the scope or value of manual training farther than to call attention to one or two of its most salient points as they are connected with our topic, the manual training of chemistry. Nor is it thought that chemistry alone of the sciences offers opportunities in this field. But, while any laboratory science offers fine advantages for this sort of training, laboratory chemistry offers some points of special adaptability.

Already the value of manual training is recognized in some of our best secondary schools, and a place is being made for it in the public school curriculum. In fact, the wide extension of laboratory methods of science teaching in the last decade or two is but the logical outcome of this trend of pedagogic thought. Yet it is to be feared that oftentimes the laboratory is considered and the laboratory work is planned to stimulate mental activity and give clear perceptions alone; while the adaptability of this work to the coordination of mental and physical is either not understood or is simply ignored.

This work can not by any means be left to the trade schools. The trade school does not give good manual training, using the term in its larger sense. Its purpose is entirely too utilitarian. Its aim is largely to make certain courses of action automatic, to train the fingers to obey reflex nerve action rather than the conscious will. Now, to enlarge the domain of reflex action and thus free the mind from attending to a mass of details is, of course, legitimate and valuable education; but that manual training is the best which adds to this advantage that of stimulated mental activity, and which supplies food for mental growth.

Let us take a simple example to illustrate this. It is far better, considering it on the side of character development, that a boy who is to learn wood-turning for instance, should be taught it as a part of a well planned course of education than that he should learn it in the best equipped practical woodworking shop in the world. Granted, for the sake of the argument, that he may learn to turn out more work and with a better finish perhaps in the shop than in the school—and even this claim will bear argument—still the purpose is not to develop a wood-turner but a character. The shop teaches him perhaps to hold his chisel in a certain way simply because it cuts better. The school must teach him the same fact and, in addition, that the grain and texture of the wood and the play of natural forces there acting are the reasons for this. There is a chance right here to work in that favorite old term "apperception," but I will forbear. In short, the shop busies his hands, the school his brain with his hands.

Another consideration, of which time will allow only the statement, is that manual training gives increased power of expression, and all education means power of expression.

Believing it to be generally conceded, then, that manual training is not only a legitimate but a highly desirable part of a public school system, I wish to place special emphasis on the peculiar adaptability of laboratory science work in general and of chemistry in particular for just this sort of development.

1 Chemistry is the first subject in which a school attempts to offer laboratory work. Perhaps 50% more of secondary schools give laboratory work in chemistry than give it in physics.

The reasons for this are that a moderate outfit is not expensive, and the cost of maintaining the work when once started is small; and again the usually overcrowded science teacher can handle large laboratory classes better in this than in other subjects.

2 The thought processes connected with an experiment in chemistry are not so involved as those of physics, and the pupil's mind is not too completely absorbed in his course of reasoning to give heed to his method of doing.

3 System and order can be more effectually maintained in the laboratory. This is possible because each pupil may and should have his own complete and uniform set of apparatus, and all perform an experiment at the same time, while duplicate sets in other science work are generally quite expensive, and therefore seemingly out of the reach of any but the most liberally supplied schools. Furthermore, the teacher may comprehend almost at a glance the kind of work being done by pupils and may correct mistakes at the outset.

4 Every experiment for its most complete success demands deftness in manipulation, adroitness in the arrangement of apparatus, as well as care and skill, and ingenuity in overcoming mechanical difficulties.

But even with these points of peculiar adaptability, laboratory chemistry will not attain the results of manual training unless the work is well directed, has continuous oversight on the part of the instructor, and is planned with those results in view. Any methodless method of turning a class loose in a laboratory to prepare some element, as hydrogen for example, and study its properties, according to the ill directed ingenuity of the pupil or the scanty and sometimes unintelligible directions of a textbook, may develop the pupil's appreciation of new ways of having a good time, as he touches a match to a bottle of hydrogen with the hilarious exclamation to his follows, "now, here she goes." But such a course will utterly fail of the most valuable results of the subject.

Personally, I have no sort of patience with the fad that says, "You must never restrict the developing tendencies and never hedge in the activity of the child, but just let him develop according to his natural disposition." Those who advocate such a course certainly have no belief in the doctrine of original sin. Our cities have large police forces, asylums, almshouses and jails just to take care of people whose natural tendencies have developed.

And so the pupil needs most explicit directions to guide him, a good, thorough manual full of directions and helps, a book separate from the textbook. For the textbook that attempts to crowd into a sentence or two of fine print the directions that may need a page or two often so confuses what was before clear that the last end of the pupil is worse than the first. And, even with the manual, farther directions and suggestions will be constantly necessary to meet special conditions as they arise.

If orderly work is expected of the pupil, then the example of orderly work must be set by the teacher. Supplies must be in readiness for the day's work and every need anticipated. Stock bottles must be clean, well stoppered and well labeled. If paper labels are used, print the names and formulas clearly and neatly with pen and ink, and coat the label, after it is affixed, with hot paraffin wax to prevent its destruction by acids, etc. Unlabeled bottles are an inexcusable nuisance in a laboratory, and in the household they have slain ten times more than the Chinese war. Stock solutions must be filtered and clean. Tin spoons may be provided at a cost of 5c or 10c a dozen for the handling of most of the dry salts. They are cheaper than spatulas and more serviceable as a rough measure. A convenient side table or shelf holds all supplies needed by the pupils for the day's work.

Let the pupil have a good complete and uniform outfit of apparatus and let him own it, then let him keep it under lock and key and be just as responsible for it as the cashier of a bank for its funds. The sense of ownership is a powerful incentive to interest and careful work. If possible let him be the sole owner, but, if not, then he should have the same privilege which any business man enjoys: that of choosing his business partner.

Let this apparatus be specially adapted and the best for its purpose, and do not ask or expect him to be interested, accurate, careful and skilful in the use of apparatus fished out of a junk pile. The best use I have for old olive bottles is to fill ash barrels. The first cost of such a good outfit is somewhat more than the junk pile, to be sure, just as the student developed by the laboratory ought to be somewhat more valuable to society than the ragpicker. But, after all, the cost of the good is not very much, and the running expense not a whit greater, since the pupil must pay for everything he breaks, at cost. Is the objection raised that such apparatus is thin and fragile? That is one of its strongest recommendations for our purpose. By all means let it be fragile. In the handling of it lies the manual training. Woe to the individual who can not turn around in a china shop without a bill for damages. His education has been sadly neglected.

Neatness, order and system are the *sine qua non* of any exact science. Teach the importance of care! care!! care!!! Never countenance dirty apparatus, slopping of liquids or spilling of powders on desk or floor. Instill some idea of what is meant by "chemically clean." While one may not go to the length of requiring the work done on spotless polished oak, yet spots should be of but rare occurrence. Let the pupil learn to be neat in person also, always protecting clothing with apron. Let him train his hands to hold a stopper properly when using a reagent bottle, to grasp the bottle, to pour out a liquid. Teach him how to get dry salts from the stock bottle on a neat square of paper, and to take no more than is necessary for his purpose, never returning any excess from his dish to the stock for fear of contamination. Teach economy in the use of chemicals, not simply for economy's sake, but because there is better training in the handling and observing of small quantities than in large. Many books direct to use from two to five times as much as is necessary.

The pupil should learn how to set up apparatus and how to plan out the connections of apparatus so that it shall be neat and trim, not bolstered up with books or other props. He should learn how to bend and cut glass tubing, how to mend broken test tubes, how to fold a filter, how to put a glass tube in a stopper, how to put a stopper in a flask without crushing the bottom in. Teach the special use and handling of retort, crucible, flask, etc., and the reasons for this difference in apparatus.

These and a thousand more constitute the manual training of chemistry; and one not familiar with the work can hardly realize how much the pupil is in need of just this sort of training. I have seen a bright, third year pupil, when given a large tank of water and a bottle, work 15 minutes trying to fill the bottle with water and invert it without success, and this was not true of one pupil alone but true repeatedly. The person who never learns to do these little things properly is the one who in later life can not drive a nail or place a screw, who can not help himself or meet the little emergencies and petty annoyances, and who in a higher sphere will lack system and executive ability.

All honor to the man who knows much, but more honor to the man who can help himself with what he knows. Education should not seek simply to enlighten the tenant of the house beautiful, but must lead him to make the best and the widest use of his mortal dwelling.

## RELATIVE VALUE OF THE QUALITATIVE AND THE QUANTTIATIVE IN LABORATORY WORK

BY PROF. W. C. PECKHAM, ADELPHI COLLEGE

Laboratory work is the pedagogic fetish of the day. It might be called the scientific "cant" of the time. It has seemed to some, more conservative than others, that there was danger of exalting too highly a valuable feature of our work, by the claim that everything should be done in the laboratory. It would however now be agreed by all that laboratory work is a means to an end, rather than an end in itself, even though much that is done in the laboratory is done for the sake of the result which is obtained. At one time teachers of history and English attempted to use the term to designate the work of their students in the library, stealing thus the "livery of heaven." Of course this was not a legitimate use of the term since the phrase should be limited to work which actually employs material and manipulates it to secure a material manifestation of some fact, and should not be extended, even in science work, to embrace the study of the history of some law, or the biography of some lawmaker. Laboratory work is, definitely, the work of the hand guided by the head.

The speaker received his college training before laboratory work was invented. And very good training it was, even in physics, at the hands of the great teacher, Snell of Amherst. It made a pretty decent kind of a scholar out of a scrub of a farmer boy. He therefore has scant regard for those who, having been made all that they are by the best system of the time, now turn about and cast stones at their "cherishing mothers." Laboratory work is good. It has come to stay. The new way is better than the old; but good men were made by the old method. Good students of science could be made now without a laboratory. Given a youth of bright, quick imagination, and he can learn so that, when the laboratory tools come to his hand, he will have an idea of their use. I am not advocating the method, I am only pointing out its possibility. I quote finally on this point from the preface of a recent textbook bearing the names of Professors Rowland and Ames:

> For a student beginning the subject, laboratory instruction in physics is of secondary importance. It is extremely useful and a great aid to the student in understanding the subject; but he can receive the mental training and learn the fundamental facts and theories without himself performing the experiments. Those performed on the lecture table need not be repeated by the student unless greater accuracy is desired.

If, then, there should be laboratory work, and there should be, of what sort should it be? Scientific experiments may be of four sorts: illustrative, determinative, demonstrative and verificative. And of each sort the experiment may be either qualitative or quantitative, or may be performed inductively or deductively. This gives us varieties of experiment to be divided between the lecture table and the laboratory, admitted to both, or reserved for the investigator only.

To determine the selection of experiments for the laboratory, it is necessary to hold clearly in mind the end to be attained by the student in experimenting. If what I have already said is to any large degree true, it is evident that the establishing of facts, laws, and theories is not the chief end of laboratory work. Some might even hold that an elementary student is not competent to undertake the demonstration or the verification of a law or theory. Prof. Rowland holds this in the preface from which I have already quoted. We are all aware that the complete verification of most laws of nature is impossible, and we so teach. Even the simple law of inertia is an instance of this. It is not well then that a student should think that he is *demonstrating* a law which even Newton knew he could not demonstrate. And, should experiments be introduced which look toward demonstration and verification, the student should be made to feel that it is but a look in the direction of a demonstration and not the full realization of vision that he is having.

If now our field is narrowed practically to the illustrative and the determinative experiments for the laboratory, we are brought to our special topic. Should these experiments be qualitative or quantitative in character? If I were required to answer this question in a word, and my answer to be in the line of my practice, I should be forced to say, quantitative. I doubt if there is one simply qualitative experiment in the various courses in the laboratories over which I have the pleasure to preside.

Probably the strongest objection to a qualitative statement is that it is liable to be inexact. For example, to say that an increase of pressure on a gas reduces its volume, is qualitative, and an inexact student is contented with so much of the truth. Pressed to state how much the change of pressure and volume is which he has in mind, he can not do it. It reminds one of

Henry T. Field's famous statement, that a "half-baked scholar is simply an underdone goose." By the way, that is a quantitative statement. The qualitative work does not encourage exactness of statement to the degree that the quantitative does. Nor does it test and train the power of observation to the same extent. It is always easier to answer the question, "of what sort?" than it is the question "how much?" An instance in point. An academy recently purchased a barometer. When it arrived, the teacher of science (the poor thing probably was obliged to teach all the sciences) unpacked and set up the instrument. To her dismay, it would not come up to 30 inches. It persisted in a most contrary manner in remaining more than two inches below that mark. I may admit you to the secret in advance by saying that this academy stands more than 1800 feet above the sealevel. The teacher probably knew the qualitative fact that barometers do not always remain at 30 inches. Of quantitative knowledge beyond this she does not seem to have been possessed. So she poured in more mercury and the obstinate liquid would not stay in the instrument. She explained to her class that the barometer had been made for the sealevel, and so must be altered when it was carried above the sealevel. Her woman's wits were equal to the emergency and she pushed the tube up the scale till it read 30 inches. As this occurred only a few weeks ago in our state, the instrument is probably reading about the same now. Remedy, qualitative training might have prevented that; quantitive surely would.

A limited and judicious selection of qualitative work may certainly be allowed for the beginner. A college student should not need such work. I notice in the excellent reports of our science committees which have practically been followed in the syllabus of the regents, that such a principle was followed by them. A moderate number of qualitative experiments are introduced in physics. Such are no. 30, the relative conductivity of solids for heat, no. 31, convection currents, no. 32, phenomena of boiling, no. 43, Chladni's figures, no. 51, lines of force, no. 53, static electricity, and some others. For every one of these the introduction into the list can be successfully defended. In reference to this work the committee say in their report (see proceedings of our meeting a year ago, page 730, at bottom) "it must be sufficiently specific and accurate to insure the learner against the inference that the facts of physics (the word science might as well have been used) are approximate; he must learn that in physics quantity is quite as essential as, if not more essential than quality. The quantitative idea must be ever present in his work." I presume there will be no dissent from that position.

If then it be concluded that the greater part of the elementary laboratory work should be quantitative, it remains to consider the method in which it shall be presented to the student. There are two methods of presentation, the inductive and the deductive. Of these the older, the deductive, has, I fear, few defenders among the talking members of our gild.

Induction is nowadays a word with which to conjure, quite as powerful a charm as is "laboratory work"; and, if any one has an attack from a doubting devil of a principal or a president, all that need be done is to hold out the holy thumb bone, induction and the saintly femur, laboratory work, and without doubt the devil will flee, leaving behind the true sulfurous effluvium. Now I must confess that I have less respect for induction in laboratory work than I have for teaching science by lecture and experiment only. I am reminded of an anecdote about the elder Dana. The old scientist was attending a lecture by his son. As he sat in the audience, two men in the seat in front of him were talking about the two Danas, not aware that one of them was sitting within hearing. At length one of them said, "Well, the boy is head and shoulders above his father." This was more than the old man could stand, and, touching the speaker to call his attention, he replied, "Yes, he is, because he stands on his father's shoulders." In this shrewd retort lies the key to the teacher's activity. He must plan to place his student head and shoulders above himself as soon as he can be boosted to that altitude. How much of the work shall be inductive and how much deductive, is to be determined simply by the answer to the question, How can I advance my students most rapidly? It is plain that a beginner can not spend time to rediscover all truth. That is the inductive method carried to its logical limit. He would never get anywhere on the road to learning if he did attempt such a task. It may be that an Agassiz was right in keeping a student gazing at a fish in the endeavor to see something for six weeks till the fish was—well, strong! But I do not believe the game—the fish this time—was worth the candle. To make a correct unbiased induction does not lie within the power of elementary students. I do not believe the average student is any better than I was at the same point in my career; and I know that I was not competent to manage an inductive piece of experimental work while I was an undergraduate. I could have managed a whale better with a trout line. I remember a laboratory book on the "Cat," for which it was asserted that the student who had worked it through would know all biology. I quote this as an illustration of the inductive method "gone to seed." Many things can doubtless be learned from a cat; but I doubt if all the kingdoms of nature are fully represented, even in that talented animal.

One of our old time professors, Marshall Henshaw of Amherst, died last week. He has opposed the laboratory most strongly and wrongly. But his reason was sound. The trouble was that there was another possible inference than the one he made: the crude and inaccurate work of the ordinary laboratory does not lead to the exact laws of science, therefore away with laboratory work. His objection was, as you see, against the inductive method. And how can a boy or girl with a string, a lead bullet, and only an ordinary dollar watch perhaps, deduce the law for the length of a pendulum in relation to its time of vibration. To me this experiment has a peculiar value, but not in the direction of inductive reasoning. In this, as in many of our laboratory experiments, it is not the knowledge of the law that we are after, nor the certainty of a fact even, but it is the training of the eye in exactness. This and the training of the hand in skill should be the aim in most of the work of the laboratory. The student can learn the laws and facts in other ways, but no man can acquire skill of hand and exactness of observation except by doing and observing. I once asked a student to bore some holes through a rod which was to be used as a lever. He bored them in all directions except the right one. Impatiently I said: "Have you no tools at home?" The answer was: "I believe the coachman has some in the stable." My parting shot was: "Well, then, the coachman's children will have all the brains, and their children, all the money too." That was a correct induction.

The preface of a recent laboratory book contains this sentence: "While in theory much is conceded in favor of inductive methods in science teaching, it is found in practice that the purely inductive method fails at points where it is expected to do the greatest amount of good." A reviewer of the book adds: "I think the experience of a great many teachers of science will bear him out in this statement." I must say that my solemn opinion is that, if inductive teaching is not a flat failure, it is only slightly curved.

And just here there is another, training for power! That is what they say we should do. An article in a recent school magazine has the title, "What can be done to make the study of physics a better training for power?" Will these people name any training which is not for power. Even the prize fighter trains for power. Try to think of any other kind of training. You can not find any other object of training.

Laboratory work must lead the student to such a knowledge of his powers as will give him confidence in himself when he comes to do original work. That is essentially a quotation from the preface to Kohlrausch's *Physical manipulations*. The point can not be better stated. And, if induction, as the student is able to carry it on, would lead him to think that the laws of science are at most about right, approximately true, away with inductive work in the laboratory! The laws of nature know no exceptions, they are rigorously right, and we had better have our students attempt only to illustrate them than to attempt to come up to their perfectness with imperfect appliances.

Here then I conclude. Laboratory work should have a definite, determinate result. The student should as the result of his experiment, find out something, deduce something, conclude something, illustrate something. And within his range of power, depending on the apparatus and his mental capacity, he should come to a definite conclusion, and should know why he so concludes.

## Section B. BIOLOGY

### FRAMING A COURSE IN BIOLOGY FOR UNTRAINED MINDS: A DISCUSSION OF PRINCIPLES

BY PROF. HENRY R. LINVILLE, DE WITT CLINTON HIGH SCHOOL, NEW YORK

Four years' experience in teaching biology to young boys of 13 to 16 years of age would be time very largely thrown away, if it had not brought before the teacher's mind a confusing array of problems. Whether a teacher traces the origin of his mental attitude back to the influence of a university, where biology is taught too often as a science without thought of the immediate mental needs of the students, or whether the normal school has given him that pleasant frame of mind in regard to the beauty of nature with little of the substance of nature, in either case it is almost impossible for him to anticipate these problems, or, anticipating them, it is almost impossible really to meet them as long as he holds his university notion that biology is the thing to be taught, or his normal school idea that the children are to be entertained. Repeated failure with the one, and the inability to develop the child's mind with the other, after a while must incline a teacher toward trying to find out what is the matter. There are just two things the matter: first, most of us have an incomplete understanding of the child's mental equipment, and, second, we fail to adjust the subject-matter and the manner of its presentation to the ability of the child to understand. It shall be my purpose in what I have to say, to make clear the necessity of knowing just what the child is capable of, and to suggest the lines along which the adjustment of material to mental capacity can be made.

Boys are not very young men, mentally, nor are they babies, but they are young animals with only the *capacity* to develop mentally. This is probably more nearly true of the east side boy of New York with whom I am dealing than it is of the first year boy in the majority of country high schools. In certain respects, however, our boy has the advantage in a comparison, for he is very shrewd and knowing. His knowledge of what the teacher will do or will not do is far more accurate than similar knowledge in the mind of a country boy. He is worldly wise, too, for how else can one explain that bearing of easy familiarity with the intense, nervous rush of east side life. But, in spite of his apparent brightness, the average east side boy when he enters the high school is undoubtedly more ignorant than the average first year boy in the country high school. Even a casual observer would notice the difference. This boy of ours has, as I say, little more than the capacity to develop. He has no power to express an idea clearly unless it be in the telling of a story, which he has learned. He has no power to originate, unless it be through the practice of guessing. In fact, he has few ideas to express, and the language he has learned is strangely unsuited for use in intellectual circles. There are many reasons for his faults, however. One of them is to be found in the lack of a cultured home influence. Another is the crowded condition of the grammar schools from which he has "graduated." Everyone knows that the sole interest in life in the ordinary Chrystie street or Mott street home is the getting of something to eat or to wear. Literature, science or the arts have little claim on the attention, except in so far as they bid fair to minister to these needs. And so, when the shrewd Jew or the quick Italian father sends his boy to the high school, he seldom does it in the hope that his son will thereby become an intelligent, cultured man, for he knows nothing of these things; but he does know that a man with education has a distinct material advantage in his world.

In a considerable degree, too, the home reflects the life and spirit of the street. Natural affection and unselfish interest are made to seem coarse and narrow by the ceaseless rush and grab outside. Suspicion seems to be a quality bred into boys from these surroundings, while timidity is the last expression a teacher learns to expect in the face of this class of New York boy. The boy believes that every one is his enemy, or, if everybody isn't, it is well to be on one's guard; and, it may ofttimes happen that the surly, rat-like watchfulness engenders in the teacher the determination to conquer the rebel through superior nervous force—the very worst way. It is better never to see the rat in the boy. The influences of the home and the street are serious enough, but the high school can fight against them all and win, as has been shown in scores of cases, but the conditions which I began to discuss bear on intelligent progress rather than moral development. The high school removes this boy from the crowd of the grammar school and places him in a wholly new environment, where—if it is not always the case, it should become so—he is treated as an independent being on whom some definite responsibility is to rest. He can no longer raise his voice in the deafening and deadening concert recitation, but must stand alone and be measured individually. The change is a severe one, and this fact must be taken into account with the other conditions the teacher has to recognize.

Since, then, the young student is to assume a definite intellectual responsibility, he must be supplied with material from which he may obtain a few ideas; not only that, but he must also be taught how to hold his mind to a definite proposition longer than it takes to guess, must be taught how to see and how to think. The subject-matter of biology is undoubtedly better than the subject-matter of any other science for the purpose of initiating the process of thinking on material things. My reasons for this opinion are these. First, there are in number more obvious facts in biology than there are in physics, chemistry or geography. The child has for that reason a more extended knowledge of plants and animals to begin with than he has of qualities of matter or of chemical processes. Second, he has a greater natural interest in plants and animals, because they, as he, are alive. Third, the student can obtain a considerable knowledge of the facts and a fair understanding of the principles of biology without the need of algebra or geometry—necessary in physics, and with little need of the ability to manipulate skilfully or to think in abstract terms—necessary in chemistry. Then, for prudential reasons at least, the material of biology seems to be the most available.

We should not, however, lose sight of the question which I hope will be answered in a general way in what is to follow—the question of whether the knowledge a first year boy may gain of biology pays scientifically; that is to say, whether the facts and principles learned in that time constitute an organized piece of knowledge with definitely related parts. My preliminary answer to that question is this: a first year course can be made to pay scientifically, if, besides taking into account the element of time, the undeveloped mind of the pupil and his lack of skill, we present the facts so as to avoid the simplest nature study work on the one hand and the elaborate dissections of college work on the other.

Our opinions concerning what should be the content of a beginning course in biology differ widely, and they differ on the basis of what we think the child *ought* to know. Seldom do we consider what the child *can* know. Let us look at the question from both points of view as one, and let us limit the discussion to zoology, at this stage, for the purpose of concentration. The subject-matter of zoology is so extensive that one may frame any number of courses, and they may all be successful in their way. One may attempt to familiarize a child in a half year with every order of animals that ever existed, in some ill defined belief that he is preparing the youth to enjoy life when he gets to be a man, or the teacher may lead the child by means of the dissection of the cat or the rabbit, and the brain of the earthworm, to an understanding of certain facts in comparative anatomy; but neither of these men has more than a one-sided view of the matter. Most courses in beginning zoology, and I may say most textbooks also, fail to consider certain essential factors, viz: first, the relative importance of topics, scientifically; second, the relative importance of topics, as teachable facts; and, third, the completeness of the course as a whole. I do not consider a course that deals only with the outside of all the animals studied a balanced course, unless it pretends to be simply what it is, part of a course in nature study; neither do I call a course that goes strongly into comparative anatomy a balanced course. Nor, from another point of view, does a course show true proportion which through its textbook gives, for example, 10 pages to the group coelenterates with one of those pages filled with an account of a certain species interesting to the author, personally, but of relatively small scientific importance. Nor, again, in a broader way, is a course correctly adjusted in its parts, if the laboratory work is not supported by critical and unifying recitations, occupying at least one third of the time. Certainly we must have passed the period when it might have been necessary to say that the knowledge gained in recitations must be tested and extended by work in the laboratory.

The second essential factor of those I have named, "the relative importance of topics as teachable facts," is of a very practical nature; not that considerations of scientific perfection and those of practical use are necessarily opposed. Everything should be taught that tends to give a clear conception of a set of facts or of a principle. It is, however, not practical, that is to say, it is unprofitable, to take any time to discuss the origin of the arthropods, the relationships of the king crab, the bilateral symmetry of the starfish, the ancestry of the lung fishes or points of a similar unsettled character. In dealing with the Mollusca, for example, time given to the discussion of such orders as the Ledida or the Arcidae is wasted, because the multiplicity of details concerning these unfamiliar and almost unimportant orders scatters the attention, and results in the formation of an uncertain conception of the salient features of the Mollusca. In laboratory work there is an enormous number of unteachable facts frequently taken up. The worst offenders in this matter are those teachers who set a young, thoughtless, untrained and unskilled child at the dissection of the cat, or at that more heinous intellectual crime, the dissection of an insect. Of course the child will learn many interesting things; but how is that knowledge related to other things he knows about zoology? The chances are that the relation is about the same as knowing the history of the 18th century without the background of a knowledge of the civilizations of Egypt, Greece and Rome. One of the chief reasons why such unbalanced teaching is done today is to be found in the personal pride of the teacher that he should be the one who taught so much to one who knows so little.

Perhaps all of us offend against the third essential factor, that of completeness of the course as a whole. Some of us plan a course in invertebrate zoology, because the children know the vertebrates already, or because the vertebrates make too much "muss." Others of us are more interested in vertebrates, and perhaps we don't know much about the invertebrates. Some of us say nothing about the Protozoa, because it doesn't pay; others skip the coelenterates, because it is so hard to understand the alternation of generations in the hydroids, or because the children know all about coral islands, anyway. Still others refuse to work with live animals, because it is thought the discipline will suffer. All of us, though, when we stop to think of it, can see that a course in zoology must be finished—something like a work of art; else how can we expect the information the pupil has gained to be an organized unit in his mind?

Up to this point I have been criticizing others. I shall now give the data for a criticism of my own course, including my ideas of how a course in zoology may be made to aid in the intellectual development of the boy who studies it.

The work in biology in the DeWitt Clinton high school of New York city embraces four periods each week during the entire first year of the high school course. From September to about the first of February zoology is given, from the first of February to July, botany. Boys who enter in September begin with zoology; while those who enter in February begin their biology with botany. We have these fixed times for the two subsciences, because we believe it is decidedly to the advantage of the teaching of botany to have it come in the spring, and quite as well to have zoology come in the fall, since the forms with which we think it best to begin the work in zoology are then alive. The results expected from the work of the boys in zoology or botany is determined by the length of time they have been engaged in work of that character. We expect more of a second term boy in zoology than we expect of a first term boy in that subject. In the laboratory work we study the following animals in the order given: 1) grasshopper, 2) butterfly, 3) crawfish, 4) earthworm, 5) sandworm (nereis), 6) mussel, 7) sea anemone, 8) paramecium, 9) fish. It will be noticed that certain types are omitted in the list, viz: the sponge, the amphibian, the bird, the reptile and the mammal. Lack of time decided the omission of the sponge. The fish was considered in a measure a substitute for the amphibian. The profitable study of the internal anatomy, at least, of the bird, the reptile and the mammal is impossible in beginning classes of 35 or 40. To supply the deficiency caused by the omission of the higher vertebrates, I have in course of preparation a scheme for the study of the habits of birds and the habits and external structure of mammal pets, such as cats, dogs, squirrels, etc. It is hoped that in the course of time those interested in the development of nature study will take up the extensive study of birds and familiar mammals, thus giving to the secondary schools, other conditions being favorable, the opportunity of making their work more intensive, but that moment may come a long time hence.

The time given to the forms mentioned in the list of nine varies from one week for paramecium to three weeks for the crawfish and four weeks for the fish. The time allotted to each topic includes the time set aside for laboratory work and the time for recitations. The total time for recitation through the half year is slightly more than one third the entire 80 periods. The laboratory work always precedes the recitations on a given type for manifest reasons. With animals like the crawfish, the earthworm, the sandworm, and the fish, all of which may be studied in the living condition, the laboratory work has three stages: first, there is careful study of the prepared specimen under the guidance of directions and questions; second, usually a single drawing is made; and third, there is farther examination of the animal, this time a living one, with a report on the method of locomotion, the method of breathing, the circulation of the blood (in the worms) and the response of certain sense organs. In work on the living animals every appearance of cruelty is avoided.

Perhaps the first criticism that might be made on this course so far as explained is that it does not follow the so-called logical order, that is, it does not begin with the Protozoa and end with the highest form studied. There are two reasons why such a plan was not followed. First, the pupils would never have heard of Protozoa, and hence could not be expected to have a definite interest in them, though they might stand in awe at the first sight of them; and second the idea of a cell is beyond their power to comprehend, bearing with it, as it does, the attendant idea of a single unit performing several functions. It is easier to think of legs for running, hands for grasping, fins for swimming, and a mouth for taking in food. Consistent with the idea expressed in an earlier part of this paper, the idea that the material of biology is valuable for educational purposes because the child is acquainted with it in a measure, and is interested in it naturally, it seems to me but logical in the best sense to begin with the grasshopper, the butterfly and the crawfish. There is another consideration outweighing either of the two just mentioned, and that is the comparative simplicity and ease of examination of the grasshopper, the butterfly and the crawfish. In view of the fact that the purpose of a course in biology is to furnish the mind with the substance for new ideas, what would be more necessary than that the facts should be easy of access and clearly detailed? We place the Protozoa near the end of the term, when it is thought the boy should have a fair understanding of the meaning of comparative morphology and comparative physiology.

The fish is placed last, since dissection requires a considerable degree of scientific interest and concentration of mind. The other forms are given their order partly on account of the availability of living material and partly on account of relative structural simplicity.

A word now in regard to obtaining practical results from laboratory work. It is a very common method of procedure to give a student a specimen and tell him to find out what he can about it and then draw it. The story of Agassiz's student and the fish is very interesting, but the idea contained in it, like many another college idea injected into high schools, is very discouraging to youthful willingness. Then there is the other extreme represented by the man who writes laboratory manuals. He says, "note this," "note that," "note the other". Of course the boy, if he knows his business, will note them all. And then the man asks questions in such rapid succession and in such endless confusion that the student may well wonder whether the author intended the book for use or wrote it to show how many questions he could ask. It seems to me that every teacher, if he has any ingenuity at all, ought to see in the first place that the Agassiz method is the wrong one in secondary schools, and then he ought to plan his own laboratory work, because the conditions in his school are, in all probability, different from the conditions in any other school. In my own case, I give far more consideration to the questions I put on the board for the boys to answer than I do to the marks I give them in examinations. My reasons for care in this matter are many. I want the work to be directed along profitable channels. I want this part of it to constitute a unit in itself. To accomplish that, the set of questions is made to begin definitely and to end definitely, the separate questions being related as much as possible to one another. Here and there among the questions are notes containing bits of information or directions to help the pupil over obscure points. The general purpose of the comparatively few questions, eight to 15, is to draw the pupil out and to make him feel, when he is through, that he has accomplished a not unpleasant intellectual task. In the answers I hold the boys to clearness and ease of expression, besides refusing to accept a paper that is not neat in form. When the set of answers, or the report as we call it, is written, the boy can be supposed to know something about the structure of the animal. The drawing can then be undertaken with understanding. I consider the drawing somewhat more important than the report, because vagueness or inaccuracy of understanding might pass unnoticed in the report and be detected instantly in the drawing. Sketchy drawings are not permitted, neither is shading, because one induces carelessness, and the other serves to cover up faults of detail. Sharp, diagrammatic outlines with modified yet clear details, may constitute a record of absolute accuracy.

With a fair understanding of the structure of the external organs of the crawfish, for example, the pupil is provided with a live animal in a tray of water. With 40 boys in a class, one may well say the fun now begins. Perhaps it isn't well to think seriously of discipline at such a time, unless we seek an early grave, but business is business, as the boys soon learn, and after the first few pinches, and the exhibitions of mock terror, the order "to work" brings every one into line with something like nervous anticipation of the "experiments," as they call the live animal work. Such observations as these are made on the crawfish: an analytic study of the order of movement of the legs; a study of the external evidences of breathing by showing the inward flow and the outward flow of currents of water with carmine; an examination of the movements of the telson and the swimmerets in swimming; and the movement of the mouth parts as an evidence of tasting beef broth. At no stage of the laboratory work has it ever appeared necessary to do things to "interest" or to "entertain" the pupil. Every indication seems to point to the conclusion that a child can have an intellectual appreciation of carefully planned and profitable work as readily as an adult can appreciate it. All the deliberate planning to interest the child in the beauties of nature is in my opinion time uselessly consumed. If we strike at broad intellectual development, the love of beauty will follow naturally.

It is at present unfortunately true in most schools that much of the time of recitations has to be given to supplying the deficiencies of the textbook. It is also necesary to interpret the textbook, when any sensible person would think the textbook ought to be self-explanatory. The function of the textbook should be to fill in the spaces between the ideas obtained in the laboratory and to fòcus the mind of the pupil on essentials. If a textbook could be written with care, simplicity and completeness of its kind, the teacher would be relieved of the task of joining ideas together and elucidating statements, and could give his energy to the proper work of a recitation, which is the use of well stated facts and principles for the purpose of inspiring clear thinking and continued study.

**Prof. W. J. Beal**—As I mentioned yesterday in my paper, I have been 25 years doing my best to help plan a course of study including a course of botany, but we have been obliged to change yearly, or every once in a while, to accommodate the new ideas that come in by introduction of new members in the faculty, some going out and others coming in, and I have given up the problem as one that will never be settled. The existing faculty will adjust studies according to their own ideas, and I presume that is the way elsewhere. There will be constant fluctuations, and the different states and universities will have their own plans. For me to attempt at this time to block out what would seem a suitable course in botany for the state of New York would be folly.

**Prof. C. G. Rogers**—I would like to ask two questions of Dr Linville. Do you find it possible to secure from the pupils adequate work on Vorticella in the laboratory; and how far would you carry work in homology on crawfish?

**Prof. Henry R. Linville**—In the work on Protozoa I have not accomplished very much, I must acknowledge. I do not give much time to work with the compound microscope in zoology; I give more to microscopic work in botany. The boys have one week for the study of the Protozoa. In that time they see living paramecia through the microscope, draw from charts (which is exceptional) and have recitations on the group.

I have attempted for three successive years to get satisfactory results from the study of homologies as illustrated in the appendages of the crawfish, but the outcome has not been fully satisfactory. The reasoning involved seems to be somewhat beyond the capacity of boys at the age of those of whom I speak.

**Inspector Arthur G. Clement**—I have had a little experience in this matter of courses of study in New York state, and I have had some such experience as Dr Beal refers to. There are different kinds of teaching in the different schools, and it is very hard to secure a uniform course. As I have prepared the papers for the examinations for the 600 schools in the state of New York, you can imagine that it is quite an effort to prepare a satisfactory paper. There are some schools that take up their zoology by beginning with the protozoans and studying that class first and then going on from the lower to the higher class, endeavoring to show the increase in complexity of structure as they advance. There are other schools where very little effort of this kind is made. They begin the study with the dissection of the frog or crawfish, and afterward study the lower forms. Still other schools will study only external features. So to prepare a paper that will cover the different kinds of teaching is quite a task. We have solved it in this way: we prepare a paper of 15 questions, and no school is required to answer more than 10; and, if any school attempts to do dissection and microscopic work to any great extent, 20 credits on the examination are allowed, provided the students submit good notebooks. As there are usually two or three or four questions involving dissection, others on life history, others on homologies etc., all are usually satisfied with the paper.

### ZOOLOGY IN SECONDARY EDUCATION

BY PROF. JACOB E. REIGHARD, UNIVERSITY OF MICHIGAN

[Paper read but manuscript not received at date of printing.]

**Prof. J. H. Stoller**—We have all enjoyed this paper, we appreciate its scientific grasp, and all want to read it when printed. I regret that there is very little time for discussion. If there are any who wish to speak briefly on the paper we shall be glad to hear them.

**Dr F. W. Barrows**—It has occurred to me that one other phase of the value of biologic studies in secondary school work may possibly be worth mentioning. We have spoken of their culture value, we have spoken of the value of exciting an interest in nature and love for nature, as is done by proper nature study, but, in addition to this, we might inspire in our schools a *respect* for the science, something a little different from any of the motives just mentioned. I wonder if it would not be possible to present to the pupils the economic side of botany and zoology, so as to give them a very much higher respect for the work that they are doing than they usually have. Can we not make use of collections selected to illustrate some of the very valuable work done by the state and national governments in this line? Can we not also make use of some of the published reports of our state agricultural boards, state entomologist, zoologist, United States fish commission and various other United States commissions? I would like to know if any one here has seen any publication on the economic results in zoology and botany which is worth recommending as a help in secondary education.

**Inspector A. G. Clement**—I wish to express my great pleasure in hearing this paper. It certainly has been a notable one, and I will speak of some points which impressed me; the points brought out with regard to the methods of physical and biologic sciences respectively. It seems to me that they are decidedly different, and the educational value of these two subjects depends largely on the method. The method of physical science is what might be called the experimental, while the method of biologic science is the comparative or evolution method. The full value of zoology is not obtained unless the student gets a thorough insight into the theory of evolution. I specially like this idea of the paper, getting the method in biology so thoroughly as to be able to apply it to history, to literature or to any line of thought which one wishes to carry out. One can not understand psychology and pedagogy as now taught without understanding zoology.

**Prof. Henry R. Linville**—In reply to Prof. Barrow's question, I wish to say that the economic aspect of biology appeals to pupils on account of its practical use; but I should not say that respect for the subject of biology comes through interest in the economic aspect of it. Respect comes rather because the subject as a whole is well presented; and because the subject is made to seem through the facts and the principles underlying them to be worth the pupils' while.

I should qualify one statement which Prof. Reighard made in his paper, to the effect that biologic training is better than the training a physicist gets. It may have been in the example he gives that the biologists were broad-minded men naturally, and the physicists narrow men naturally. I have known biologists who were very narrow and physicists who were very broad. The difference between men of different or even of the same line of study depends on more than one factor. Most prominent among the factors that should be taken into account in judging men are their natural ability, the quality of their training in their special line and the extent to which they have an acquaintance with other lines of thought and experience.

Another matter which I should like to discuss now is one which Mr Clement mentioned. Instead of offering so many chances for a boy to pass the examination in biology, there ought to be an effort to test his knowledge of the subject. I know from personal acquaintance with candidates that boys who have received the 48 counts in the regents examination have been admitted to the Cornell medical school. Now, they were admitted because they received those counts and not because they were prepared for the work. It seems to me that, if the regents stood for unifying and systemizing the work of education much more than they do now, the result would be more helpful to our educational system than their present methods promise.

**Inspector Clement**—I beg to disagree with my friend. I think that, if we were to present an examination which was always along a certain fixed line, there would be a reaction against the study of botany and zoology. The equipment of the schools is so different, the preparation of the teachers so varied, that, if we were to insist on a certain fixed line of teaching, there would be objections throughout the state. The regents are not autocratic. They are willing to allow for the greatest breadth in teaching throughout the state. In fact, they are compelled to; otherwise, they would hear something from the schools. The schools would say, "Very well, we will withdraw." We are gradually working toward a course, but it is utterly impossible to insist on a certain fixed course in every school at the present time.

**Prof. Linville**—It seems to me the situation is something like this. When the board of regents accepts the work of the boy and grants him the 48 counts, it puts the stamp of approval on the knowledge the boy has. It would appear that the boy had sufficient knowledge to enable him to enter the Cornell medical school with advantage to himself, but boys soon learn in many cases that they are ill prepared for such advanced professional study. If the regents examinations were real tests, they would give a correct and not an incorrect notion of what a boy really knows.

## Section C. EARTH SCIENCE

### THESES ON GEOGRAPHY

**Prof. Frank M. McMurry**—1 The basal units of geography should be taught far more fully than has heretofore been the case.

2 The proper presentation of these units calls for 1) numerous excursions; 2) type treatment of topics.

3 The type treatment of topics provides for much more frequent and effective reviews than have been customary; a provision highly important.

4 There is an extensive causal sequence of facts in geography, the beginning point being physiographic and climatic conditions.

5 Type treatment and causal sequence of topics throw much emphasis on the relative value of facts; but more attention still must be given to this matter, for perspective is woefully wanting in the geographic knowledge of the schools.

Prof. McMurry discussed each of the foregoing theses.

**Inspector C. F. Wheelock**—I confess to being somewhat surprised by Prof. McMurry's statement that basal units are not taught. So far as my own observation and experience go, I am led to believe that teachers are giving special attention to that very matter. In a large majority of the schools that I see, teachers are continually collecting material which shall aid in giving the greatest possible degree of reality to those preliminary notions. I certainly think that the facts are not so serious as Prof. McMurry has been led to believe.

**Sup't Jay Crissey**—I think Prof. McMurry has just stated what is true; and, in addition, that it is well nigh impossible for the children to grasp these basal units till they come in contact with them. In a mountain section it is easy to teach what a mountain is, but a child will not understand the opposite formation. Some years ago I taught a sixth grade in Chicago, in Col. Parker's school. Geography is taught there in as good a manner with as good aims and purposes as I ever had any conception of its being taught; yet these children on the prairie have very little idea of a mountain. They could tell that it was a large hill, and yet, when they came to be questioned, they had no conception of a mountain with its sides seamed with ravines, its streams of water, its forests and vegetation. Often the teachers failed to realize the necessity of these units being understood by the children.

The first of last month I was talking to an institute with regard to studying outdoor forms right about the schoolhouse and using them to build up ideas. I sketched a hill on the blackboard and made a contour map of it. Soon a teacher asked me if I really supposed that a child ever came to school who didn't know what the map meant. I said, "I believe most of the teachers here do not truly interpret maps." I illustrated by the country from the St Lawrence river to New York, following the line of Burgoyne's march; I asked the teachers to put down lines, one after the other, which would mark the profile of that march. Then I put on the board the correct diagram, and turned to the teachers and asked all who were wrong to hold up their hands. Nearly all were wrong in some particular.

**Prin. Frank Carney**—I would like to state a brief method of teaching the soil which one of the teachers of Yates county tried at my suggestion. He removed some residual soil to get down to the shale rock, took a small quantity and pounded it up fine, placed it in a tomato can, planted some beans in it and kept it on a stand where the pupils could see it. They saw that the beans grew, that the soil had been made from the rock; I think they got a practical idea of that one geographic unit.

**Prof. Grant Karr**—As regards the type theory I do not feel free to say much, because a man who is working in geography specially, like Dr McMurry, ought not to be confronted by a mere schoolmaster; but the matter as presented might possibly be compared to the alphabet method of teaching reading—taking small and to the child unimportant matters out of their relation and making them the chief thing. It is a question whether these types as such should be taught in the lower grades in a formal way. Would not such a procedure go beyond their powers of analysis and generalization? I do not see how children in the third and fourth grades can get a conception of a city which would be complete enough for future use. Such a type must be left unfinished and kept growing for some time. It is not an easy matter to explain definitely what a city, a town, or a farm is. To say just what a city is requires a great deal of thought on the part of the person describing it, if he have a great deal of experience, and the elements can not be undrstood till the person has had much experience and practice in making generalizations. A young person goes into a town in much the same condition as Yankee Doodle was—unable to see the town for the houses. He has not really a general notion to make up a type of a town till he can think the matter out of its elements. This may be one objection to the type theory.

**R. H. Whitbeck**—I am sorry Dr McMurry was able to give the fourth topic so little discussion. I think it would surprise many students of geography and some teachers if they traced out the *causes* of some of the great facts in geography. A single case will illustrate. We teach that New York is the Empire state, first in commerce, first in wealth and first in population. Ask a pupil *why* this is so; ask a teacher. He may tell you—he may not; perhaps he has not thought so far as that. Are you aware that 90% of the wealth and and 80% of the population of New York are found in a relatively narrow strip of land bordering the Erie canal and the Hudson river? Here then is a suggestion of the cause of New York's greatness. But why was the Erie canal built in New York and not in Pennsylvania or elsewhere? There is of course a reason for it. There is in the eastern mountains south of the St Lawrence river only one gap and that is in New York. The only opening through which could be built a canal to connect the interior of the continent and the Atlantic seaboard was in the Mohawk valley. And why is the gap there? We find that, toward the close of the glacial period, the Great lakes were compelled to drain through the Mohawk valley. A gorge was cut through the mountains at Littlefalls by this river, and the subsequent building of the Erie canal became possible. The Erie canal was the great factor in giving New York state preeminence. This is an illustration of the causal idea in geography.

## PERSONAL EQUIPMENT OF TEACHERS OF GEOLOGY AND GEOGRAPHY

PROF. ALBERT P. BRIGHAM, COLGATE UNIVERSITY

It is recognized in this paper that the teacher of science in the secondary schools is usually burdened with many subjects. Our suggestions, therefore, must be moderate if they are to be helpful, and we must seek to set up practicable ideals. Notwithstanding the demands of science teaching at the present day, no teacher should be daunted by lack of early training. With interest in nature, and due use of the opportunities which offer themselves, some parts of the field can be well covered. It is not so important that the teacher know everything as that his interest be genuine and his knowledge vital so far as it goes.

Among the essentials of the teacher in our special province is some measure of experience in the field. It is our most important laboratory. The teacher must know how to observe, and take notes out of doors. One can learn to observe only by observing. If this can be done under direction, it is well, but, if it must be alone, the results, in spite of limitations and blundering, may be even better. No better phenomena can be taken than those of the glacial drift. They will often be puzzling, but they will compel thought and be fruitful. Record all possible facts seen in a section of gravel and sand or of boulder clay. The causes or relations of what you see may not appear. Do not be disturbed by this. Go on to another section, and observe and record in the same thorough manner. You will soon find yourself comparing, contrasting and theorizing. Then you will go home and begin to read all that you can find on the subject. When the teacher has reached this stage, he will scarcely need formal instruction. The habit of science will have been acquired.

I do not hestitate to advise the verification in the field of the observation of others. It is not original work, but it will lead to independent inquiry, and often open the way to new problems and to valuable observations over local areas. This leads me to refer to a remark of Sir Archibald Geikie on what we may call the democracy of the science of geology. The same is true of geography. The highest training is not too good for either, but much may be done with something less. Here witness the long roll of amateurs who have made honorable contributions to the science of geology. The careful study of local geologic sections and the exhaustive gathering of their faunas or floras, is one field for such work. One need not be an accomplished paleontologist or have large experience of field methods in order to do this in a region of simple structure. So also descriptions of local physiography may be of great value. For the greater part even of our older states such descriptions do not exist, and here is open a wide field of interest for teachers. The results in personal satisfaction, in teaching power and in scientific production are beyond measure. Such work carried on even imperfectly, or in isolated fragments of time, will infuse power into all school duty and impart a truly professional dignity to the teacher's vocation.

Closely related to our plea for field work is the emphasis which we now place on full knowledge of some phase of our subjects. What should be chosen for such intensive study will depend largely on circumstances. It will be of great use to know thoroughly any local industry which is based on geology. All industries belong to geography or have geographic relations. To put it concretely, a teacher in southwestern New York might well seek to be thoroughly versed in the oil industry, its history, its distributions, its methods in the field, and the refining and marketing of its products. Before going far the teacher would find himself deep in the geology of ancient formations on the one hand, and on the other ranging broadly the field of human interests. Similarly, rock salt may be taken up by the teacher in western New York. The Great lakes and their commerce would soon involve one in the study of ancient formations, in fascinating problems of physiography, in the movements of early discovery and in the industrial development of a continent. Building materials, the glacial drift, and the founding and growth of cities, are other obvious subjects of great interest. A full, rich, and, as far as possible, first-hand knowledge of any one of these subjects will free all the teacher's information from the flavor of bookishness, and it is not an impracticable ideal, requiring only purpose, and some centralizing of attention for a period of months or years.

What we may call the fellowship of science should be fostered by every teacher of our subjects. No teacher, however ill prepared or diffident, need be cramped and discouraged by isolation from his fellow workers. In the cities are many local academies of science, historical societies, or literary clubs which are hospitable to scientific studies and contributions. The writer's first published paper in geology had place in the transactions of a historical society. Fresh knowledge of the home locality always finds a welcome, not only with pupils of a school, but with intelligent patrons and thoughtful citizens of the community. This association exists largely for the purpose of scientific fellowship, and, it is to be hoped, may lead to much interchange of thought and of the materials of teaching. Particularly should this be true as between the schools and the colleges. Departments in colleges should be used by the schools, and the instructors in such departments should be freely called on for such information or other assistance as they may be able to render. The American association for the advancement of science is not a monopoly of specialists, but in its general membership is designed for all who have interest in the study of nature. Its annual dues of $3, now include a year's subsciption to *Science*. In many cases the school library might meet the annual charge, receiving the periodical and giving the teacher the benefit of the membership. The American bureau of geography, having its headquarters at Winona (Minn.) should also receive the attention of teachers of this subject. Its quarterly bulletins are full of useful papers, and arrangements are made for interchange of material. The cost is but $1 a year. In one or more of these ways the teacher may realize the invigoration of personal fellowship and greatly enlarge his personal satisfaction and his power.

The teacher should not fail to accumulate some store of literature, either as a private possession or as a part of the school library. The writer has elsewhere given an outline of suggestions of this nature for geology;[1] and good bibliographies for high school work in geography are now easily procured. In addition to such periodicals, government reports, textbooks and other works as are available, it will be found useful to gather out of current periodical literature, accounts of geologic and geographic facts and occurrences. When one directs his attention thus to the magazines and daily press, one will find a surprising abundance of such material, which is always used with vivid effect in the classroom. This has never been more fully true than now in our own time, in the opening to knowledge, interest and action of so many obscure or remote parts of the earth.

## THE PURPOSE OF GEOGRAPHY

### BY PROF. AMOS W. FARNHAM, OSWEGO NORMAL SCHOOL

The purpose of geography must be in harmony with the purpose of education. The purpose of education is to aid in stimulating and directing the child's native energies and impulses in such a way that the best possibilities of his being and doing may be realized.

Some definite idea of what geography is must be arrived at, before its purpose can be defined. Geography, as a subject of study, is a system of thinking organized on a fundamental idea. This fundamental idea seems to be man's physiographic environment; its origin, development, and influence on his life. Geographic elements have been and are of value to man in accomplishing his purposes. They have also furnished impediments to human progress and development, of various degrees of strength. It is the purpose of geography to take into account all physiographic elements, in a related way, which are of use to man, and also those which hinder his progress. How then shall the purpose of geography be realized?

Man's physiographic environment is made up of different land and water forms of different origin and different stages of development; these forms, with their attendant fauna and flora, exert different influences on his life; and they are put to different uses in accomplishing, what seems to him, valuable ends. These different forms appeal to him differently, causing feelings of admiration, satisfaction, awe, fear, according as his mind may be affected by experience, necessity, superstition. The child's feelings determined by his environment should be directed toward knowing his environment. At first he considers the various earth forms of his district more in the light of sources of enjoyment and means to pleasant employment. He has not looked on them as furnishing materials for food, shelter and clothing, either directly or indirectly, because these physical needs have been satisfied by those to whom his care has been intrusted. The hill which has been climbed for the joy of climbing and for broader outlook, may furnish material for the study of all vertical forms. Its slopes vary in length and steepness, and therefore vary in their power to retain moisture and soil elements. The different slopes have different exposures to sunlight. The vegetation of the hill varies on different slopes and on different parts of the same slope. The vegetation varies in number of species and in quantity and quality of each species. Then a relation is found between vegetation and animal life. The life of the hill observed during the year will serve to illustrate the phenomena of life under different climatic influences. The meadow which has been the theater of athletic sports may have even greater interest when considered in the light of its origin. The meadow and hill together illustrate the relief of the child's district, and furnish basal ideas for the study of all relief.

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[1] Suggestions to accompany a textbook of geology. 20th century series.

Every child has discovered for himself the power of running water to turn wheels; also its power to float objects on its surface. He has learned something of its force in the destruction of his dam. He needs but a single word that he may observe its eroding power in the deepening of its channel, and the process of silting in the shallowing of the more quiet portions of the stream.

When the life of the brook is studied, and its life compared with that of the hill, children find striking differences that awaken a spirit of inquiry. Why can some animals live in water and not on land? Why can some live on land and not in water? Why can some live both in water and on land? Why can some plants live only under water; others only with their roots in water and their stems in air; others still wholly out of water? A likeness between plant life and animal life is here discovered, and the characteristic structure of plants and animals is found to be suited exactly to their life habits.

The streams of the child's neighborhood, no matter how small, and the ponds as well, illustrate the drainage features of his neighborhood. When the relation of drainage features to relief is considered, it is discovered that drainage is modifying relief, and that relief in turn is modifying drainage, since relief determines the direction, force, velocity, and length of streams. It is apparent that relief and drainage determine human settlement, human industries, and lines of human intercourse.

Children who get their basal ideas of geography from contact with the earth, receive more than purely intellectual knowledge. They get material for the exercise of the emotional side of their natures; for in the study of the hill and meadow, the brook and pond, the field of grain and the lowing herd, as objects of geographic interest, the learner instinctively observes something else that lies beyond and above the purely intellectual. He observes the graceful outlines of the hill against the sky, the meadow framed in goldenrod and flecked with marguerites, the rhythm of running water in a pebbly bed, the restful pictures of the crystal pond, the billowy grain and patient kine. Then each of these becomes a part of one harmonious whole, and the landscape broadens to the horizon. He looks upward and cloud scenery against an expanse of blue greets his vision. He observes the myriad colors, both strong and delicate, in their varying shades. The odors of springing vegetation, of flowers, fruits, and "new-mown hay," attract and interest. He hears the sound of wind and bird and bee. The unbreathed air invigorates his whole being. All of these qualities of nature that do not enter into direct geography teaching, and can not when the earth herself is not approached and studied, appeal to the higher nature, refining and elevating the child. While the wholesome exercise of the emotions plays an important part in the development of moral character, it should be remembered that on their exercise depends largely the success of all intellectual training.

It is one purpose of geography to show the intimate relations between earth forms and climate; to show that earth forms modify and even make the climate of a given place; to show that the climate of a given place retards or hastens the development of the earth forms. But the effects of climate are more readily seen in the life of the place, specially in the plant life. The climate of any zone may well be illustrated by the weather of almost any temperate latitude district. For example, a summer drouth causes scarcity of ground water, which in turn affects vegetation, domestic animals, and local commerce. A drouth that makes "short" pastures affects dairy products. When meadows are dried, a small amount of inferior hay is harvested. When growing grain is checked by drouth, there is a small growth of straw, with many shrunken kernels. Drouth at certain seasons causes some fruits to fall and others to ripen prematurely. Then some products that can not be dispensed with find a ready sale at an advanced price, though of an inferior quality, because the supply is not equal to the demand, and there is no satisfactory substitute. Again, some products of inferior quality can not be sold at a price that will pay for their marketing, because they have substitutes that are more satisfactory. When the learner comprehends with clearness and intelligence what drouth is, and in what way great heat and little moisture affect vegetation, springs and streams, and just what these effects are; and also how these effects affect animal life and local commerce, then he will be able to understand what are the permanent conditions of an extended area having continued drouth year by year, notably the Sahara. And at this time the influence of continued drouth on human settlement, industries, commerce, and civilization may be comprehended.

It may be said that one purpose of geography is to show how man in a measure has freed himself from physiographic control by modifying the physical influences about him. In regions of unestablished drainage man has supplemented artificial drainage. In arid districts, by means of irrigation, the desert has been made to "blossom as the rose." Some idea of the diversity of agricultural conditions within the limits of a single state may be gained from the fact that there were held within the borders of Texas a few years ago, at nearly the same date, a drainage conference and an irrigation convention. One was at Galveston and the other at San Antonio. Some persons were thus studying means of lessening the amount of water over a large area, while others sought to increase it, or rather to make its supply for agricultural purposes more regular.

In localities not well supplied with wholesome water, artesian wells have been made to furnish inexhaustible quantities. Man has bettered his climatic conditions by protecting the forests of slopes and destroying the forests of swamps. All this may be regarded as having an intimate and vital relation to the social, industrial, commercial, and through these to the moral life of the people, so that, one might say, a purpose of geography is to reveal the influence of environment on human life—not material influence only, nor commercial influence, but esthetic and, indirectly, ethical as well.

The child's nature in its feeling aspect is developed by geography along the line of love of home. Home consists of many elements, chief of which is the love of father and mother, and friends; but these have a physical setting consisting of houses, streams, forests, industrial pursuits, etc. Love of home deepens and widens with the life of the child. It begins at his father's fireside; then extends in widening circles, including larger and larger areas till the outermost circle coincides with the boundary of his country. Then home and country become synonymous, and love of home becomes love of country. Love of country is strengthened and perpetuated through knowledge of one's country. When the American youth learns from geography the extent of his country, its resources—mineral, vegetable, animal, and manufactured, and when he compares his country's extent and resources with the extent and resources of any and all of the great countries of the world, he realizes of a truth that the lines are fallen unto him in pleasant places; that he has a goodly heritage.

Geography greatly influences and largely determines man's thinking and doing. History is a record of his thinking and doing. Geography is the body; history the soul. Geography supplies the knowledge of the means for accomplishing human ends.

## Section D. NATURE STUDY

### BIRDS IN NATURE STUDY

(Abstract)

PROF. ELON H. EATON, BRADSTREET'S PREPARATORY SCHOOL FOR BOYS, ROCHESTER

The rapidly increasing study of birds and bird life is due in part to the general awakening of interest in nature; but there is also a widespread feeling that the numbers of our native birds are decreasing rapidly, and it is only by instructing the rising generation in the value of birds and the ways of protecting them that we can hope to preserve the varied, beautiful and highly beneficial species which are disappearing before the onward march of railroads, telegraph lines, plate glass windows, electric lights, milliners, wood-choppers, ditch-diggers, English sparrows, murderous boys and untutored men.

There is however a great inherent value in bird study. Children are interested in life, and birds are the most alive of all animals. Their highly specialized structures and life activities, their motion, song, language, arts, architecture, community interest, travels and personal traits are highly suggestive to the youthful mind. In this department of nature study there is also a chance of directing the dawning moral sentiments which can not be neglected. To tell children that life is sacred and nothing that lives should be killed is weakly, sentimental, irrational and contrary to the laws of the universe. Boys should be taught why, when and what to kill; not, never to kill.

The teacher of birds must know not merely technical biology but also the natural history of birds; and teach the general structure, relations, habits, food, song, flight and special adaptations of the different families and the common individuals of each family. Let the boys and girls become acquainted with our bird neighbors and their occupations. And when they know them as well as their own friends and recognize them as easily, they will become good bird protectors.

### NATURE STUDY AND THE GRADE TEACHER

BY ANNA BOTSFORD COMSTOCK, CORNELL UNIVERSITY

Success or failure of nature study in the immediate future lies with the grade teacher; for, if it is to be introduced as an integral part of our education, it must reach the pupils at last through the ministrations of the teacher in the graded schools. It is true today that comparatively few of the grade teachers are properly trained in nature study facts and methods, and this in itself seems discouraging. However, it has been our experience that teachers in the public schools of this state devote themselves unselfishly and nobly to their work. They do not question whether a new measure means more work for them. If they believe it is a good measure, they will adopt it, however much it may cost them in extra labor and care. No doubt the extensive courses of study given in most of the nature study manuals have discouraged the untrained teacher in the past. She does not see how she can teach so many things unless she takes time for a college education, which is usually out of the question. As a matter of fact, it is not necessary that the teacher be extensively trained in science in order to teach nature study successfully. The real solution of this question lies in the teacher becoming interested in some special line of study that shall connect the indoors of the schoolroom with the out-of-door life. She may become interested in birds, in insects, in animals, in flowers or ferns, or in the study of the clouds or rocks. If she learns to care for any one of these subjects and calls the attention of her pupils to it in a sympathetic manner, she has done more for the child from the real nature study standpoint than if she had taught him the whole gamut of nature study in a perfunctory manner. It is much better to teach a very little in nature study well than it is to teach superficially very much.

The main object of teaching nature study at all is to stimulate the child's interest in his out-of-door environment and lead him to a true understanding of the wonderful ways of nature; and nothing so quickly eradicates from the child all interest in out-of-door life as to be obliged to commit to memory many facts observed by others.

One hopeful thing in the outlook for nature study is that the grade teacher may find it a great help in her other work. She may correlate it with reading. However, it will be of no use to her in this unless she be wise enough to let the pupils make the observations from nature first and then let them read what other people have observed concerning the same things. To read about an object before studying it robs it of all interest so far as the child is concerned. Specially will the teacher find nature study helpful in the work of drawing. If the child is interested in drawing at all, he likes to draw something about which he knows, and prefers to draw from nature rather than to copy from a book. So too with the language work. If the child must write about something, he prefers naturally enough to write about the thing he has studied. Not only does he prefer to write about this, but, as a matter of extended observation, we find he writes better English on such topics than on those which draw on his imagination purely. The teacher of geography today is obliged by modern methods to teach more or less of nature study, and, if she is interested in this line of work, she will find many ways of vivifying the child's geographic knowledge by this close contact with nature. From every side we have evidence that, above all, nature study is helpful in preserving discipline in the schoolroom. The mischievous child has at last something in which he is interested; something in which his teacher is a fellow student; and this sense of companionship has proven the greatest aid to the teacher in maintaining her control over her difficult pupils.

It is not necessary that the teacher give a great amount of time each day to nature study. Indeed, very much of it may be done without any lessons at all during school hours. With aquariums in the windows, with cages containing insects and animals in the schoolroom, and with window gardening, the teacher will find that the children will learn the things for themselves if they have the opportunity of watching. All she needs to do is to give sympathetic and intelligent attention to their observations.

### NATURE STUDY IN PRACTICE

PRIN. E. J. COBB, BUFFALO, SCHOOL NO. 60

When the leader of this division asked me at a late date for a paper on the practical side of nature study, to be presented before you, the past masters, as it were, of the subject, I hesitated about complying, thinking that anything I could say would surely be old and threadbare to those whose life work is the study of nature. However, I decided it might not be out of place to tell a little of the "old, old story" as it has appealed to me, a student, in my attempts to apply the subject with school children, in the vacation schools and also the public schools of Buffalo.

In these days when "fads" are charged with all the evils "flesh is heir to," the question is often asked with reference to nature study, "Is it a practical thing, or is it theoretic—a fad?" So much has been said and written about the subject, often contradictory and often erroneous as to scientific facts; so much has been done and proposed to be done, that thinking people believe to be the veriest nonsense, that it is no wonder parents and friends of our schools ask us, and justly, to explain how we expect to benefit the rising generations by this, to them, new subject. We as educators know the subject is not new, and that very little of a new character has been proposed or written. It is only an old, old friend, masquerading under a new name, with new clothes and rejuvenated being. The Great Teacher taught by appealing to the concepts gained through nature study, and made his teachings practical by establishing a close relation between the natural object and the life of man. "Consider the lilies of the field, how they grow; they toil not, neither do they spin: and yet I say unto you, that even Solomon in all his glory was not arrayed like one of these." Again he said: "Behold the fowls of the air: for they sow not, neither do they reap, nor gather into barns; yet your heavenly Father feedeth them. Are ye not much better than they?" The poets have always taught through nature, and have made the subject of practical value by leading men to see its beauties and relate its every phenomenon to their lives. Shelley's *Cloud* contains a whole volume of science to be gained by the observation of nature.

> I bring fresh showers for the thirsting flowers,
>   From the seas and the streams;
> I bear light shade for the leaves when laid
>   In their noon-day dreams.
> From my wings are shaken the dews that waken
>   The sweet buds every one,
> When rocked to rest on their mother's breast,
>   As she dances about the sun.
> I wield the flail of the lashing hail,
>   And whiten the green plains under,
> And then again I dissolve it in rain,
>   And laugh as I pass in thunder.

Is there a city street, however poor and mean, where the clouds, as Shelley saw them, could not form the basis of a term's work in practical nature study? The first stanza suggests the study of moisture, its distribution and relation to plant life, the sea, the stream, the bud, the flower, condensation, evaporation, hail, snow, with all their attendent phenomena, and all related through personification to the life of man. As I remember, nearly all the objects referred to in Mrs Wilson's complete course in nature study were found within four squares of a great city.

As a student, and to test the practibility of nature work in the city, I volunteered to try to direct that part of the work in one of our Buffalo vacation schools last July; and this work, supplemented by that done in my own school under more favorable conditions, forms the basis of the observations and comments here given. This experiment no doubt was made in an unscientific manner, but it will better serve as the "terrible example" of mistakes committed.

Theoretically every lesson should be carefully planned; the teacher should have gone over the ground and become familiar with all that is to be seen; a certain definite, well defined aim should be in the mind of teacher and pupil; the preparations should be perfect; and the class should be under perfect control during the whole lesson. The teacher should also be a scientific nature student, a nature lover, a close child student, an experienced, broad-minded person, trained to see relations, and having the power to establish them in the minds of the children. Alas, is it strange that we as teachers stand appalled at our lack of the necessary training to carry on this work? We rush away during the summer vacation to observe and study nature, and with pencil in hand and book in arms—the specter of failures past and of brilliant achievement to come, hovering near—are told just how to study the bird, the bee, the plant, the tree, and we return to teach the children as we were taught, to pour our scientific study back into their already overburdened minds; and the parents say—never mind what.

I plead guilty. I had listened to nature teaching for two summers, had read much on the subject, and thought some; but, face to face with the real problem, the children, I confess that my theories and methods had to be subordinated to the desire to do the child some real good, to give him some practical, living truth that would help him in the battle of life and fill his darker hours with gladness. The first problem was to obtain a real live interest, to have the child feel and desire to go out and investigate natural objects. Next, to find where these objects could be found, and, after the observation, to make practical use of them in developing the child. We had 100 children, and only 20 half days in which to work, with sewing, manual training, drawing and literature to be considered. There were five different classes working independently of each other, and yet it was desirable to establish a relation, a unity, in the whole, which should work out in a higher life, a fuller and more enjoyable one. Similar problems confront everyone who desires to make the subject fruitful, and we as educators are writing and telling how it can best be done; yet the more we study the problem, the more we find in it to solve.

In the vacation school I endeavored to establish a general interest in my branch of the work by simple experiments, all bearing on a general subject, the weather. These experiments, to the children, at first, partook of the nature of magic, and I, for the time, became a wonderful magician. When they were told that they could do the same things for themselves by learning nature's secrets, the magician in me vanished and all were ready to go forth and discover other truths from the greater magician, nature. These central and general experiments on the weather were simple, easily performed by any teacher. Such ones as floating a needle on water and allowing it to come to rest pointing north and south, were used to establish our directions for the study of winds; experiments showing the evaporation of water and the condensation of vapor prepared the pupils for the study of cloud formation; work with magnets gave them an idea of attraction; the electric spark of frictional electricity helped to explain lightning; while the firecracker on July 4, made practical thunder.

This study of the weather, together with these and other experiments, naturally led to talks of the influence on our lives, of rain and snow, of dew and frost, and of the sunshine and the winds. By question they soon discovered a relation between the weather and the soil, the soil and the plant, the plant and the animal, the animal and themselves—a higher type of animal. This furnished a natural division of work in the different classes. One class was sent out to study the rocks, the mother of the soil, that the weather had pulverized or rounded or broken into fragments; to decide what ones had been most easily broken up by rain and frost and air and water. From this a brief classification into hard and soft, rounded or jagged was necessary. The next desire was to know what they contained, and thus the subject of metals and minerals, and their uses to man was taken up. It was a surprise to me to see how many of these boys, sons of workmen, became enthusiastic over this work, and seemed to grasp its practical value to them.

Another class naturally desired to study the things coming from the soil, the plants and flowers. They saw that the rain made them grow, the frost injured or killed them, the wind scattered their seeds and so helped them to live again, while the sun furnished the light and warmth to make them grow, blossom and bear fruit. Then came the questions as to why the plant blossomed, and the use of the seed in trying to reproduce its kind. They saw the efforts of plants to live, and asked the question why they were here, and of what use to us. This led to classification into good plants and bad plants, weeds and flowers, and the uses of each in nature.

The work on rain suggested that one class be sent to study the brook and the river and the life of each. This class constructed aquariums and studied this phase of life at close range, its needs in order to live, its habits, its food, and how these animals differed from the land animals. They found tadpoles, fishes and water beetles, and discussed their relations to vegetable and mineral life and incidentally the early life on the earth.

The study of the air brought up the subject of the inhabitants of the air, and a class was set to work on the birds, bees and insects, and their relations to the vegetable world, their classes and habits.

Thus the study of the weather and its influence on human life and on the animal, vegetable, and mineral kingdoms created the desire to investigate in the different classes, and furnished a common ground where all could meet and compare the interesting things each had observed. More experiments were given along each of these special lines, and the children seemed happy in doing the work. They were ready to observe, and to give practical expression to what they had seen in the drawing, manual training, and language classes. The stories in each class were along the lines of their nature study, and thus new interest was given to the work. The sacredness of life, coming from and cared for by the Creator, was the central thought in all of the work, while close classification and scientific naming of species were a secondary matter.

What a field for common thought, mind and conscience awakening we found in this study, as we discussed our duties to animals, to plants, and to each other. Perhaps we only accomplished a small part of what we desired to do, and yet the working toward the great unity of our lives with all life, all nature, helped to solve for us the problem of the field lesson. The children needed no special preparation, the teacher none, as all went forth to solve a question in which they were interested; and many succeeded.

Was it of practical value to the children? you ask. To give these children, even from the lower walks of life, some idea of the history of the earth's formation, of the making of the soil, of the best soil for plants, of the uses of minerals and metals, of the relations of animal, vegetable, and mineral life, of the habits of insects, birds, and bees, of how nature adapts herself to varying environments and tries to become as perfect as possible, of her exact laws of life; and, over and above all this, to see the beauty, order, purity and truth in all her manifestations, is surely of practical worth. To give this glimpse of a fuller, higher life has a value not to be estimated, and those who receive it best will become the best citizens, the greatest poets, scholars, and philosophers, the best housewives, artisans and scientists.

In the limited time allowed us in the vacation school we could only plant the seeds, and trust the future to carry on the work begun. I trust the little done may prove as great a benefit to these children as I know it has proven to the children of my own school, where it has been possible to watch the results more thoroughly. Classes in six different grades have been sent out the past term for a general field lesson, during the time of an afternoon session; and, while I could give many illustrations of the far-reaching results of even a single field lesson, it will not be consistent, in the time at my disposal, to refer to more than one or two of these, as given to me in the reports of the teachers, themselves.

One class of second year pupils was sent out last October to observe primarily, plants and the dissemination of seeds; secondarily, the general preparations of nature for winter; and to gather materials that would be of use in their winter lessons. As a preparation they were told what to observe, and cautioned against indiscriminate collecting, the summer work of the plant was reviewed, and each was asked to provide a box for the objects collected. On the trip they observed birds, domestic animals, four classes of trees, many varieties of plants, and the work of water in land sculpture, besides making collections of seeds, nuts, leaves, cocoons, egg masses, etc. In the report asked for on this lesson, two months later, in answer to the question, in what subjects the teacher had found the field lesson most helpful, she answered: "In language, reading, drawing, and in fact all subjects of the school course." Asked for definite examples of the benefits derived, and her opinion of field work in general, she replied as follows: "In the field lesson the children derived a clearer idea of the individuality of the plant, they studied nature in her own home. They took note of the different conditions under which the plants grew, and what kinds were most abundant in the locality visited, and were led to question the why and wherefore of what they observed. Afterward, they seemed more interested in our nature talks; shy ones forgot their diffidence in their eagerness to tell what they had seen 'out in the field that day'. Many of them made other little trips to the woods and fields the weeks following, and the accounts of what they had seen gave evidence of a markedly increased closeness of observation. There was noticeable, too, a quickened appreciation of the 'dignity of nature', less of 'I will bring it here', and more of the 'I will go and see' when there was a doubt on any question in plant study." Farther, she replied: "As to field lessons in general, I think there is a possibility of incalculable good to the child in the way of training his observant faculties and developing in him that fine perception of the beauties of nature so helpful in after life."

Other teachers gave fully as encouraging reports from their field lessons. In two grades I furnished mimeograph copies of 10 questions which the class were to answer from their observations in the field lesson. These proved helpful and aroused much enthusiasm. All were asked to keep their answers secret till they were asked for in the class.

In conclusion, allow me to say, that I believe it is as necessary to interest the teacher as the pupil in this work, by placing her in contact with nature, and thus developing in her the love of the subject and a desire to know more of it, without any attempt at first to have her give it a scientific study. My observations lead me to think that children, even in a large city, already know much about nature, but they need to see the relation of these natural objects to their lives. They dislike scientific names and classifications, but love the real living subject and practical experiment. They lack motive for study, which definite problems for solution would give them.

Teachers need no special training so much as they need a strong desire to help the child to see and to think of his relations to the rest of the universe; to see the beauty, unity and completeness of God's work, that both child and teacher may love all nature better because of a more thorough acquaintance with her wonderful secrets.

**Mrs A. B. Comstock**—Some discussion came out in Mr Eaton's paper that I would like to speak of. He spoke of enforcing the game laws. Now one thing we ought to do for our children is to teach them to respect the laws of the state. I do not believe in letting children grow up in the belief that laws are something to be avoided. First of all, we should realize that we have a duty to the state; the sooner the child learns that the better, and no other place to begin is so good as the game laws. If the children were interested in the game laws and in seeing them enforced, we should find a different condition of things.

Then the building of bird houses. There is an excellent book written by Lange, which tells you how to build houses for the different kinds of birds, the openings and all that. Then there is another book that I want to recommend as a nature study book, or rather magazine. *Bird lore.*

———I would like to say a word in reply to Mr Eaton. It takes a good deal of courage to say that I am the friend of the English sparrows, and I won't go into the detail of that now. But it is a great mistake to teach the boys to shoot them. There is such a thing as the lust of killing, which seems to be implanted in the masculine mind, and, where there is a desire to shoot the English sparrow, there is a desire to shoot just one more. Mr Eaton says, himself, that he reserves the rarest things for the bright scholars. In the same way I think they are tempted to shoot just one more. I wish to enter a protest with regard to the shooting. My own observation has led me to think that the English sparrow is quite as much sinned against as sinning. I have observed him carefully for three or four years now, and I think there are some things to be said in his favor. My observation is not that the English sparrow is altogether crowding out other birds; he is very much crowded out all summer long, he has no resting place for the sole of his feet except the street. The other birds come and take his nest, eat his food and crowd him out, and altogether I think he is quite a persecuted bird in Rochester.

———I would like to give a practical illustration along this line. There is great danger in allowing the boys to shoot the sparrow. There is a line of trees near my residence, and thus I have birds in my vicinity. Part of the trees are in my back yard. In trying to protect the birds during the last season, I found that I was obliged to go back there and ask the boys what they were shooting. "Why, a sparrow", they would say, but I found they were more often aiming at some other bird. Do you see the point? The remark was made this morning that we need to know the kinds of birds. Possibly, when they do know them all, we can give them permission to shoot the sparrow. I find them shooting the best song birds we have. They do not distinguish the sparrow from any other bird.

———Is it not a difficult matter to be always able to tell the English sparrow? There are so many birds so much like the English sparrow.

**Prof. John W. Spencer**—I am glad to see so much interest manifested in nature study. Speaking of the matter of the discrimination of boys in killing birds and making collections of eggs, I would say that, when I was a boy, if we got a license of an inch, we usually took an ell. I do not know how detrimental the English sparrows may be, but, for my part, I am keeping them this winter. Mrs Spencer calls them her English boarders. I have watched them a great deal and have wondered if they were as disreputable as they are alleged to be. I have also been interested in Prof. Cobb's paper in regard to his method of teaching by field excursions. That is a very important thing. Mrs Comstock gave you a very clear account of the methods of the teacher in Oakland; and, where nature study is taken in that way, you will find that it is a vast help.

### GENERAL SESSION

## MORAL VALUE OF SCIENCE STUDIES

BY PRIN. FRANK CARNEY, KEUKA INSTITUTE, KEUKA COLLEGE

Education is a sort of war which can never be avoided by arbitration. The warfare has been waged from the beginning; it was precipitated without cause, it was born with man. No matter how elementary or how complex may have been our progenitors, every advance has had a cost. So insistent has been the contest that man would decay without it; this very struggle or motion from age to age has induced mental currents that are daily storing the magazines of his achievements.

Mental discipline may be obtained from almost any study. To secure this discipline, it is quite immaterial what studies our schools offer. Hence other reasons must be considered in determining school schedules. The future vocation of the student, the ideas of the parents, and of people who have no children and never expect to have any, the whimsical school men, and the wise publishers of textbooks, must each have a hearing. The man who can economize the valuable time of our boys and girls, the coterie that would have censors proscribe and prescribe the books of our schools, and the nerve specialists who would keep children at home unless the schools can be reduced to a Chinese sameness are people who betimes occupy public attention on school matters. And now at least one member of this association would urge that our primary, intermediate and high schools give more time to science studies because of their moral value.

The purpose of education, besides what it does for the individual, is to "insinuate into hereditary influences noble aspirations"; to induce in the developing mind, at the greatest possible saving of time and effort, the epitomized development of the race; in other words, to aid the individual in finding the focus of social tradition. We are born with certain demerits of inheritance which our training must lessen, if the race moves upward. It would seem then that the particular training which can attain this end is the one most desired. There is no neutral ground in character activity. There must be growth positive or negative. The growth is always from within outward. The function of the teacher is to inspire the pupil, so to direct the growth-propelling flame within him that only the embers of right living may glow into the heat of life. Books and teachers are the forces; hence the great responsibility which educators have always felt.

The inculcation of morals was formerly the province of religious preceptors; now either morality or immorality, or both, is taught by every man, and even the dead are made the occasion of much moralizing. We are all magnets of everyday ethics. But these mind or soul magnets always have poles of unequal strength: they comply with the laws of the physical magnet. Whenever a fellow-man comes into your magnetic field, the needles swing. These moral magnets are charged in the process of education, when the positive pole should be made the stronger; otherwise, while the individual may not suffer greatly, the race can not rise. The teacher, then, is the prime character-former; for time and eternity his vocation has no peer. How best to handle the developing mind is always an open question with pedagogues. To certain dicta has been given quite universal sanction, but our professional methods are usually in ferment. So many targets are used in order to "teach the young idea how to shoot." We agree that, as the child grows, the power of observation is first developed, then the ability to conceive abstractly and finally his mind stimulates itself, he reflects. If there be a "royal road" to knowledge, it is observation, along which one may "read as he runs." The earlier stages of man's rise from primal simplicity must have been attained entirely through observation. The sciences which are observational in the large were first developed; the study of philosophy marks a complex stage of the race. In every age the perceptive faculties have dominated the strongest men; they saw what their fellows did not see. Other things being equal, the man who sees most is always the wisest man; his seeing is not one-sided, his thinking is liberal, his truth is complete. Observation stimulates the imagination and begets reasoning. Studies then that develop the powers of observation make a basis for moral growth.

But we fear there is no consensus of opinion as to what constitutes genuine morals. With the individual at least may it not be a vitalizing sense of duty? The old saw, "honesty is the best policy," has made many men appear moral; society has strait jackets that necessitate the same shamming; to show favors with the idea that they are merely lent is not self-sacrifice, it is egotism. To obey civil laws through fear of the penalty inflicted on lawbreakers, to observe hygienic requirements that one may avoid pain, to practise economy in order to feast the eyes on gold, are not the promptings of an actuating sense of duty; obeying laws because they are laws, protecting the body because it is the abode of the mind, and living providently that society may never be burdened with our support, are admonitions that duty gives to every man. If there is any line of school training that enhances such a sense of duty, let us foster it.

Farthermore, there are very few absolute dicta in morals. Practices approved by one generation may be tabooed by the next. Among morals infallibility is sought in vain. Among the Greeks and some older peoples so strong a moral sentiment was not attached to the subject of veracity as is today, specially among the Teutonic races. Why the change? The political economist would say, because men have learned that it does not pay to lie, that business faith is ruined by falsehood, or that confidence in business is established as misrepresentation dwindles. In the evolution of society certain moral rules have become current, but experience or the effort to establish harmony between man and circumstances is the concrete origin of these rules. Slavishly conforming to practice or custom does not involve an exercise of the moral sentiment. Is moral feeling ever induced save by a conflict of emotions? And, when the same emotions have frequently come in contact, may not the moral feeling give place to habit? But every such habit represents a struggle which involved complex experiences of the race. On what then does the moral progress of the race depend? In ethical acts there is both a rational and an emotional element. We must grow in accuracy of moral judgments, and must increase the field to which we apply such judgments. The attainment of these ends can be hastened by our schools. Caution is a salient characteristic of strong individuals, and is nowhere better developed than in the laboratory or by applying the laboratory method to school work.

"As a man thinketh, so is he". Would you direct the moral growth of the youth, then control his thinking. How can this be better done than by arousing his interest in all that is about him, the flowers, animals, rocks, the heavens, all nature? Thought is sometimes a subliming process; again it is destruction, distillation, when the ash is the precious product. Greek and Latin classics afford much desirable and healthful inspiration, but now and then a bit that is not refining. If the student, owing to limited time in school—and 80% of our boys and girls, we are told, never get beyond the grades—must forego either the languages or the sciences, he will become a more active moral unit in society if trained at least in visible nature, which affords endless stimuli to which his mind, if properly attuned, may respond. There will be few gaps in the time of one thus instructed.

All activity bespeaks progress; sluggishness usually means retrogression. The devotee of science must be a laborious man, in whom there is always moral force. One who continues in science study is constantly cultivating a greater love of truth for its own sake; such an attitude of mind is essential to the noblest moral growth.

As a partial criterion in estimating the extent to which morals can henceforth be influenced by science study, it may be well to review briefly the moral victories already ascribed to science. That science has lessened crime is too axiomatic for discussion. The inventions of the scientific bent in men's minds have changed savages into beings of social habits. Want of occupation makes men of the barbarous tribes dangerous to one another and to their neighbors; industrial pursuits fill the time and science moves along. The economic inventions of the scientists have always preceded the abolition of serfdom. With the passing of slavery violence has usually decreased. Another concomitant is the removal of the stigma formerly attached to labor. No greater victory, though indirect, can be accredited to science than this position won for labor; on it is based the present even too narrow conception of social equality, of the "universal brotherhood of man".

Political Europe was altered by the invention of gunpowder; the decline of feudalism was hastened by it. The common and middle classes as infantry could cope with the barons as cavalry. The franchise was extended. The idea of equality before the law followed. These are changes that mark stages in the work of the industrial spirit which was created and has constantly been fostered by science.

Science has remodeled quite completely our conceptions of God and the universe; it has constrained the influence of dogmatic teaching. We have set aside many of the older theologic ideas. Copernicus and Galileo gave us the true world and real universe, discoveries which have exalted man's conception of divinity; now we see majestic mind where before was awful fixedness. For 1500 years the church possessed three facts about astronomy: that on the fourth day the sun and moon were made; that at Joshua's command the sun and moon stood still; and that in answer to Hezekiah's prayer the sun backed up 15°.[1] Supernatural intervention has given place to the unvarying law of a wisdom beyond man's complete comprehension; witchcraft and its attendant evils have vanished. The reign of religious terror which accompanied a theology out of joint with scientific truths had a pernicious moral effect. The emotional instincts suffered at the contemplation of the barbarous persecution. Fear is never a factor of reform. The rack and wheel may destroy the body but not the mind. To perform duty for its own sake is a precept of science; duty complied with through fear does not involve moral activity.

Science study has evolved in the race a sympathy that results in good works; it has made true humanity practical. Biology causes man to stand in wondrous admiration before the manifestations of divine wisdom; all life, even the microscopic organism, commands awe and receives it. We have come to love the laboratory spirit, that is, to love truth for its own sake, to rejoice in the very search for it; every law thus educed is divine law; the act of finding it is the revelation; the human agent through whom this scientific spirit has worked is verily "inspired". In the certainty and fixedness of nature moral life has its real conception. Blind belief, drowsy acquiescence, and childish faith are the earmarks of puerile man. The two year old rests from all fear in his mother's arms; the calm stability of the universe and the quiet measureless forces of the earth life past and present should equally sooth men in moments of unrest. In becoming men we pass through three stages: "faith, doubt, rational belief or knowledge." Knowledge of his environment and sympathy with all his fellows enable[2] man to get the most out of life. Thus is illustrated broadly the uplifting or moral developing value of science studies at any stage of human progress.

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[1] Calthrop, Rev. S. R. "The debt which religion owes to science."

[2] J. G. Schurman, in publication of the Liberal club, Buffalo. 1892. p.42.

In creating powers of observation and reasoning the laboratory ranks abreast at least with any other factor of our educational system. The notebook necessitates seeing, the deductions require reasoning; combined, these develop in the student a method which he applies to all his work, and to which he is subject even on Sunday. The laboratory gives full significance to nature and life. We intelligently appreciate that which we understand. Nature in the large inspires reverence; in detail, "rational belief", which is a requisite for moral feeling. When the methods of science become universal, we shall have a more definite standard of morals. When all men shall have acquired an average of observational and reasoning power, there will not be such wide differences of opinions on the solution of questions involving morals.

In literature are found many grand lessons that impress the virtue of honesty; pages of citation from the Good Book down might be given. Nevertheless we hold that nowhere in all the world is honesty so successfully inculcated as in the laboratory. From the very first day there the boy or girl learns the necessity of exactness, of hewing on the line; the penalty of every deviation from facts is not inflicted in vain. Besides this lesson of honesty, laboratory methods cultivate the judicial temperament; constant suspension of judgment is exercised in science work. In the public schools of a republic it is highly essential that every means of teaching honesty, caution and consideration be employed.

In origin and purpose the sciences are closely identified with the social life of man. The aggregate experiences of the human family constitute the data of science; the end of scientific research is invariably the betterment of the race. For the fullest development of social man, the law of mutual help is quite as essential as in the plant kingdom. "No man can live entirely to himself." Nearly all moral concepts are altruistic. The interdependence which the science student observes in the several kingdoms typifies the condition under which men may live best. No particle of matter can be isolated; every portion, animate or inanimate, contributes its quota to the general welfare. Is it too much to expect that in the course of time science teaching may instil in future generations the fact that all property should contribute to the support of the government which makes possible the ownership of property? Nature's socialism is disclosed by science study.

And we have a right to expect much more from this study. A knowledge of natural laws should increase respect for civil laws. It seems paradoxical that under a form of government where everybody has something to do with making the laws, there should be any disrespect for law. Men do not so much question the right of laws, but they quibble at compliance; they lack a vivid conception of duty. Again, the study of nature develops the esthetic sense in us; the poetry of nature and the representation on canvas of scenery are evidences of this fact. The pleasure we experience in painting, music and sculpture is beyond analysis; such pleasure has been manifested largely by peoples of higher intellectual intelligence, and possibly more keenly by those who have had training in the sciences. Music itself affords the same discipline acquired in some laboratory research. Geography is a science; history is best taught by the scientific method. The two combined and properly presented should give a sort of sociology, a science studied principally in colleges and universities, but which is properly a subject of the schools. No other combination of subjects is more profitable for impressing on pupils the moral value of sympathy with the law of natural selection. Enterprises flourish and cease, cities are founded and vanish, nations rise and fall, and species become extinct, not without cause. Normal body and normal mind are two requisites for the real enjoyment of life. The law of selection ultimately has its way to the extent that we are lacking in these two particulars. There is still another end which we trust a more general study of the sciences may attain. We must acknowledge that throughout the world, even in this republic, a majority invest war with a sort of moral grandeur. In the volunteer service there is a self-sacrifice which even in a bad cause is counted heroic. When men in general have a loftier conception of the purposes of energy, when they learn that brawn is not essential to heroism, that chemical action is not necessarily a civilizing agent, and that human life is always sacred, then warfare and all its accessories will be relegated to the province of pugilism.

The benefits derived from the study of science should not be denied those who never reach the high school; more science should be taught in the grades and grammar departments. The great amount of work now required in the public schools rather precludes the introduction of much more; but the educator who by correlation or otherwise can arrange courses of study which include much of the essentials as advanced by this paper, and get the courses adopted in our schools, will certainly be a benefactor of his race. While not wishing to arrogate too much to a particular field, yet it appears to me that this theme is an important one.

> Science is indeed no panacea for human depravity; but no one can become imbued in any measure with the spirit of science—the spirit of unselfish, courageous, reverent truth-seeking—without some degree of moral uplifting. Literature and art may express and incite the basest passions. Science—truth—is never impure.[1]

Science attests the unity of the universe; on the existence and establishment of this unity all moral concepts must ultimately rest. Science study impresses, in a way the older theology and philosophy can not, this wonderful unity, as instanced by the revelations of the spectroscope, the correlation of force, the ever present ether and gravitation, the common law of heredity and transmutation of species, and the referring to a common force the several manifestations, heat, magnetism and light. In his study of science as not to such a degree elsewhere, the student learns that events are not shaped by chance. One of the grandest achievements of science is the establishment of the fact that this world is regulated by natural law. When the laws of the universe are acting, God's will is expressed. In the apparent falling into disrepute of some theology, science alone can avert misfortune. For some time much so-called agnosticism has arrested attention. Theologic teaching as rearranged by science enables the religious in man to develop with his consciousness. In the present age faith without science can accomplish little; faith with science is power supreme.

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[1] Rice, W. N. Science teaching in the schools. Boston 1889. p. 11.

**Prof. Charles W. Dodge**—I am sorry that, owing to the late hour, there will be no time for discussion of Prof. Carney's paper. It impresses me as one of the most thoughtful that has been read at this meeting. We shall have to go on to the next paper on the program.

It seems very fitting that we should close the literary part of our exercises by hearing what has been done for the junior naturalists, boys and girls. It is something of university extension, of the scientific laboratories of Cornell bringing the work done there into the comprehension of the young scientists of the state. I have no doubt that if the boys and girls of this state were to take a vote as to which is the more popular, Santa Claus or "Uncle John," it would be a tie with the chances in favor of "Uncle John."

I have great pleasure in introducing John W. Spencer, who is to tell us about the work of the junior naturalist clubs.

## WORK OF THE JUNIOR NATURALIST CLUBS

BY JOHN W. SPENCER, CORNELL UNIVERSITY

When a naturalist reaches out with his scoop net in an aimless way, he will sometimes catch some queer specimens. This is just what the president of your association did when he went out hunting for some one to tell you about the "work of the junior naturalist clubs." He caught a red schoolhouse man—one who is a farmer by profession and practice and has that calling in every fiber of his body; who has enough science not to plant his crops or kill his hogs by the sign of the moon; who was raised in a family with no brothers or sisters and has no children of his own; and who could not get a teachers certificate even in the times of the civil war, when men teachers were scarce, because he could not spell.

A man of this sort ought to feel, when standing before an audience of such attainments as this, like the traditional cat in a strange garret. You need not, however, extend toward him any of that sort of sympathy. He has all the assurance of the daring fool who would rush in where scientific and pedagogic angels fear to tread. In all seriousness I would say that a large part of what measure of success we have had in nature study has been due to a nerve born of ignorance of the path that lay before us. We thought it better to start and not be ready than to be everlastingly getting ready and never starting.

In giving you a few paragraphs explaining why an agricultural movement comes to be in the schools of the state, I must tell you that nature study is a part of the work of university extension of agriculture—a movement called for by a small band of farmers in Chautauqua county in 1894, and is therefore in the seventh year of its history. The present speaker of the assembly, Hon. S. F. Nixon, secured the first appropriation, and has given all the succeeding ones his support and influence. The College of agriculture of Cornell university has been made the administrator of these appropriations to the end of taking the experiment station and College of agriculture to the farmer. About four years ago active measures were taken toward accomplishing the latter. First the farmers reading course on the correspondence, or Chautauqua plan was installed, the period of study continuing only during the winter months, the farmer's leisure time of year. During the first winter the names of 1500 farmers were enrolled. Now we have more than 20,000.

Placing agricultural teaching in the rural schools has long been a favorite theme with friends of the farmer. The management of this extension movement fully appreciated the importance of such a step. How to get it there was a question. To have asked the legislature or department of public instruction to do so would have been met with refusal; for as special legislation it would have been bad, both in principle and policy. Nevertheless, we have been moderately successful in getting it there. I must confess it was accomplished by subterfuge—by false pretense. It was done by giving the rose another name, that of nature study. The fact that the average teacher in the rural school is deficient in subject-matter in affairs pertaining to rural life was well understood. To give some equipment in this respect a series of leaflets has been prepared for free distribution, calling the attention of the teachers to many common things about them.

The first issue was entitled, How the squash gets out of the seed. Other topics followed, such as, How the candle burns, Four apple twigs, A children's garden, Some tent makers, Hints on making collections of insects, Leaves and acorns of our common oaks, Life history of the toad, The birds and I, Life in an aquarium, How trees look in winter, Evergreens and how they shed their leaves, A summer shower, Little hermit brother, A handful of soil, and what it does, Stealing a ride, The red cow and the maple tree, A bulb garden, Cuttings and grafting, The burst of spring, The early birds, Opening of a cocoon, A brook and its work, Insect life of a brook, How plants live together, or Plant societies.

We have the names on our mailing list of not far from 25,000 teachers who are receiving our literature on these topics. It has been very pleasant to receive requests from so large a number, and the frequent complimentary words are joy to the soul, but such does not always mean business. How many of the numerous subjects were transmitted to the children, we could never tell, and we felt the need of establishing some relation by which we could feel the pulse of the school. Besides, to a small number of teachers there are conventionalities in instruction as imperative as those of society in making calls and leaving cards. Such teachers have no power to initiate and are never suspected of generating spontaneous combustion and are as incapable of enthusiasm as a graven image. Again, there are others who feel safest in giving instruction as they were taught. There are a dozen other phases of the personality of teachers that make it desirable for us to have our thumb on the children—not to supersede the teacher but rather be her helper in sympathetic cooperation.

We spent a year skirmishing to find the lay of the land before formally launching our scheme for organizing junior naturalist clubs.

Last June closed the first full-fledged year of its trial, and our clubs numbered about 1500, with a membership of over 30,000 and but a small per cent in poor standing for nonpayment of dues.

To make a feature of this kind popular with children, you have only to give it the type of something similar with grown-ups.

The following are our instructions for organizing clubs.

### INSTRUCTIONS FOR ORGANIZING A JUNIOR NATURALIST CLUB

If one is to be happy, he must know something of the things with which he lives. He should love the plants and birds and the out-of-doors. In order to help every boy and girl in New York state to love nature, we are encouraging the organization of junior naturalist clubs.

Every junior naturalist club should elect the following officers: president, vice-president, secretary, treasurer; to act for a term or period to be determined by members of the club.

The duty of the president is to preside at all meetings, see that the officers fulfil their respective duties and perform such other functions as usually pertain to that office. The qualification for this office should be force of character to do his duty as the officer sees it. He should have kindness of heart to be ever mindful of the quiet, unobtrusive members, to treat all with justice, to have no favorites, and to inspire harmony and enthusiasm.

The duty of the secretary is to keep a record of the proceedings of all meetings and attend to all club correspondence, such as forwarding monthly dues and the treasurer's report to the Bureau of nature study, Cornell university, Ithaca N. Y.

The duty of the treasurer is to attend to all accounts of the club, to make monthly reports on blanks that will be furnished, showing the names of those who have paid their club dues either by letters or drawings, and those who have not, and the reason why; also names of new members since last report and members dropped from club.

As soon as members have paid four dues and thereby have become entitled to the badge, a report should be made of the fact. All reports of the treasurer should be given to the secretary that he may inclose them with the monthly dues that are sent to the bureau of nature study.

Any member receiving the largest number of votes shall be declared elected to the office for which he was nominated.

The declared object of the junior naturalist "is the study of nature, to the end that every member thereof shall love the country better and be content to live therein." All boys and girls living in the state of New York, who bear recommendations from their teachers, are eligible to membership.

Any number of four or more may constitute a club.

Immediately after the election of officers, a report of the organization, on a blank herewith inclosed, should be sent to the Bureau of nature study, Cornell university, Ithaca N. Y.

As soon as possible after the receipt of such report, the bureau will send a club charter. If the club wishes to christen itself with a name, such will be inscribed in the charter.

*The club dues.* Most clubs have dues, and so have ours; but the payment is required in work, not in money. Each member is expected to tell Uncle John at least once a month by letter or by drawings what he has seen and thought on some topic in nature study suggested by the teacher or by the bureau of nature study. These dues can be paid during the English and drawing periods.

The standard of excellence of dues is not based on scholarship, but on the member telling in his own way what he has seen and thought. It is hoped that he will not imitate the parrot by repeating what he has heard others say. Drawings relating to the nature study topic will be as acceptable as letters or compositions. These monthly dues will be interesting subjects for both the English and drawing periods.

On the receipt of the fourth acceptable dues from any member in good standing, a badge pin will be sent, to be worn by him as a testimony that the owner is entitled to all the honors due a young naturalist. Badges are never sent to hire boys and girls to join a club.

If members wish, they can send their written dues in the form of a letter addressed to Uncle John. When the secretary mails these dues and the treasurer's reports, the postal address should be "Bureau of Nature Study, Cornell University, Ithaca N. Y." The record of each member will be kept and the letters examined by a member of the bureau staff. Letters relating to personal affairs or special inquiry should be addressed to "John W. Spencer, Bureau of Nature Study, Cornell University, Ithaca N. Y."

**This work is carried on under an appropriation made by the state of New York for university extension of agricultural knowledge, and all work done by the Bureau of nature study is free to all the children and teachers in the state.**

On receipt of the roster from the newly organized club we send a monthly lesson, and plan to have the topic germane to the season. It is optional with the club what subject it considers for the month, but as a rule the topics we suggest are the ones discussed. At this period our suggestions in the monthly lessons concern Tracks in the snow, Four apple twigs, Birds' nests, How a candle burns, Galls, Starch factories, Winter insects, etc. The present is our most barren time for the formation of new or the reorganization of old clubs. We are not in the least disturbed. With the first cases of spring fever and the first notes of the bluebird, new clubs will be coming in thick and fast. I told you a moment ago, that last June our clubs numbered about 1500 and our membership a little more than 30,000. At the opening of the present school year, with the changes of teachers and of children in the grades, the situation of last June was as badly mixed as a pack of well shuffled cards. Our only way for resuming work was to begin at zero—reorganize clubs beginning at one, the same as if we never had had any before. We expect, with great confidence, to close the present year with a larger membership than last, notwithstanding the fact that we now have but 643 clubs and 17,059 members. We know what the spring fever will do.

I am wondering whether our method of presenting our subjects to the children meets with your approval. I hope it does, but I fear it does not. We make no attempt to present formal classified science. We try to think more about the child than of the subject-matter. You must not forget our mission lies with the children of the farmer, the butcher, the baker and the candlestick-maker, few of whom reach the high school, and seldom do any reach the university. If any of them shall come into the realm of your teaching, I trust you will find them better students for having had their attention directed toward nature study.

In the case of members of clubs found in the lower grades and a few even in the kindergarten, we direct attention mainly to observation; to seeing what they look at. When the child becomes more advanced and is able to understand what some of the things he sees stand for, we lead him on in a direction of cause and effect. On the older members we try to impress two principles as pertaining to all life, first, motive, i. e., self-preservation and reproduction of kind, and second, ingenious methods for accomplishing such ends. For instance, under the head of seed travelers, we make prominent the fact that the thistle cares so well for itself that all the warfare of the husbandman and competition with other plants will never exterminate it. The plant can not change its location, but it gives its seeds a splendid opportunity to travel to places where strife and competition are at the minimum and the soil congenial. Just now we are giving the junior naturalist clubs the subject of starch factories and source of raw material and motive power. When they come to you, I think you will find them with a keen desire to know the physiology of the leaf and plant, because of their investigations with iodin and observation of the leaning of the foliage toward the light.

We try to save the teacher all possible trouble. We prefer that no stated time be given to the consideration of our topics. Beginning with early spring, an aquarium in the schoolroom—and often it is a rude one—will rival a game of marbles. Its care can be made a post of honor to the child, and the school will find more questions than a Solomon can answer. The payment of club dues correlates with language and drawing.

**Prof. Charles W. Dodge**—In giving his bit of personal history, Mr Spencer was too modest to state the fact that he has more nephews and nieces than anyone else except Uncle Sam. I think you will agree with me in deciding that, if there has been any teacher present at this meeting, we have just listened to him. I have never heard any one who has the natural gifts of the teacher to a greater extent than "Uncle John." It is very wonderful how he has succeeded in interesting the class of children composing the clubs. Though he has told many interesting things, I know he has not told half what he has done. He has done more in scientific instruction than most of the instructors of the country, and the work which the junior naturalists do is just as "original" as that of advanced investigators.

## MEMBERS 1901

When the name of an institution includes the name of its town or city, the latter is not given. Where no state abbreviation appears, New York is to be understood.

**Allen**, Charles M., Pratt institute, Brooklyn
**Allen**, John G., Rochester high school
**Anderson**, W. W., Westminster school, Dobbs Ferry
**Andrews**, Kate R., University of Chicago, Ill.
**Arey**, Albert L., Brooklyn
**Armstrong**, Charles H., Workingman's school, New York
**Arnold**, J. L., DeWitt Clinton high school, New York
**Atkinson**, George F., Cornell university, Ithaca

**Babcock**, Edward S., Alfred university
**Barber**, H. G., DeWitt Clinton high school, New York
**Bardwell**, D. L., sup't of schools, Binghamton
[1]**Barrows**, Franklin W., Buffalo central high school
[1]**Beach**, Channing E., public school no. 23, Buffalo
**Beach**, Grace B., normal college, New York
**Beadel**, Charles W., normal school, Indiana Pa.
[1]**Bean**, Charles M., Pulaski high school
**Belknap**, Emmet, sup't of schools, Lockport
[1]**Bennett**, William M., Rochester high school
**Benoliel**, Sol D., Adelphi college, Brooklyn
**Bevier**, Marie L., Peter Cooper high school, New York
**Bickmore**, Mary E., Mount Vernon high school, New York
**Bigelow**, Maurice A., Teachers college, New York
[1]**Bishop**, Irving P., Buffalo normal school
[1]**Blackall**, Gertrude C., 342 University av., Rochester
**Blossom**, Margaret, Packer collegiate institute, Brooklyn
**Bogert**, Marston T., Columbia university, New York
**Bond**, W. E., Potsdam normal school
[1]**Boniface**, Sister M., Nazareth academy, Rochester
**Booth**, W. M., Cortland normal school
**Bowers**, Emma, 100 Hector st., Ithaca
**Brace**, Edith M., 131 Park av., Rochester
**Bradley**, Theodore J., Albany academy
[1]**Brigham**, A. P., Colgate university, Hamilton
**Bristol**, Charles L., New York university
**Britcher**, Horace, medical college, Syracuse
[1]**Brownell**, W. A., Syracuse high school
[1]**Brownlee**, R. B., Titusville (Pa.) high school
**Burgin**, Bryan O., Lowville academy
[1]**Burlingham**, Gertrude S., Binghamton high school

**Call**, Richard Ellsworth, Erasmus Hall high school, Brooklyn
[1]**Callahan**, E. B., Richfield Springs high school

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[1] Attend the Rochester meeting.

Carey, E. L., St John's college, Brooklyn
[1]Carney, Frank, Keuka institute, Keuka College
Carpenter, Idalette, Maplewood (N. J.) high school
Carss, Elizabeth, Teachers college, New York
[1]Case, L. V., Washington Irving high school, Tarrytown
[1]Cate, Eleazor, 16 Ashburton place, Boston Mass.
Cattell, J. McKeon, Garrison on Hudson
Chambers, V. J., Geneva high school
[1]Chesebrough, Thomas U., Littlefalls high school
Chollar, Sarah V., Potsdam normal school
[1]Christian, Elizabeth, Glens Falls high school
Clapp, B. G., Fulton high school
Clark, John Anson, Ithaca high school
Clark, O. D., Brooklyn boys high school
Clark, Tracy E., Brooklyn boys high school
Clarke, John M., New York state museum, Albany
[1]Clement, Arthur G., Regents office, Albany
[1]Cobb, Charles N., Regents office, Albany
[1]Colby, E. C., Rochester atheneum and mechanics institute
[1]Comstock, J. H., Cornell university, Ithaca
[1]Cooley, LeRoy C., Vassar college, Poughkeepsie
Cornish, R. H., Wadleigh high school, New York
[1]Crawford, A. Myrtella, Buffalo central high school
[1]Crissey, Jay, sup't of schools, Penn Yan
Curry, C. M., Cortland normal school
Curry, Mrs Sarah E., 70 N. Main st., Cortland
Curtis, Arthur M., Oneonta normal school

Dann, Mary E., girls high school, Brooklyn
Davenport, Charles B., University of Chicago, Ill.
Dean, Philip R., DeWitt Clinton high school, New York
[1]Denham, Henry H., Buffalo central high school
DeShow, Charles H., grammar school no. 58, Buffalo
[1]Dodge, Charles Wright, University of Rochester
Dodge, Richard E., Teachers college, New York
Doll, Carrie L., grammar school no. 37, Buffalo
Doremus, C. A., College of the city of New York
[1]Duvall, C. A., Syracuse

Elliott, Arthur H., Flushing
Emerson, Josephine, Pratt institute, Brooklyn
Erickson, Dan E., Chicago Ill.
Evans, Susan, 205 Court st., Rome

[1]Farnham, Amos W., Oswego normal school
[1]Fish, Pierre A., Cornell university, Ithaca
Fleming, Mary A., 432 Pearl st., Buffalo
Fox, Ada H., Masten Park high school, Buffalo
Freley, J. W., Wells college, Aurora

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[1] Attended the Rochester meeting.

Fuller, R. W., DeWitt Clinton high school, New York
Furman, Bertha M., Miss Veltin's school, New York

[1]**Gage,** O. A., Geneva high school
Gage, Simon Henry, Cornell university, Ithaca
Gaines, E. V., Adelphi college, Brooklyn
Gano, Seth T., Edmeston
[1]Gardner, George S., 141 Clifton st., Rochester
[1]Gemmel, Marion, Masten Park high school, Buffalo
Gibson, J. J., Wadleigh high school, New York
[1]Gifford, T. I., Pike seminary
Gillmore, Gertrude, Froebel academy, Brooklyn
Glavin, John F., St John's academy of Rensselaer
Goodrich, A. L., Utica free academy
Gorton, J. Irving, sup't of schools, Sing Sing
Graham, W. P., Syracuse university
[1]Greene, W. J., Hoosick Falls high school
[1]Greenwood, John W., Masten Park high school, Buffalo
Griffis, Henry L., New Paltz normal school

**Haanel,** Eugene, Syracuse university
Hale, Albert C., Brooklyn boys high school
[1]Hall, James H., Cazenovia seminary
Hallock, William, Columbia university, New York
Hancock, W. J., Erasmus Hall high school, Brooklyn
Hanna, Jennie P., Rochester high school
Hargitt, Charles W., Syracuse university
[1]Harris, C. Everett, Rochester high school
Hastings, George T., Cornell university, Ithaca
Hering, D. W., New York university
[1]Herrick, Lillian B., Elmira free academy
Hixon, Kate Burnett, Peter Cooper high school, New York
Hodges, G. C., Utica high school
Hopping, Roy, 129 4th av., New York
Hoxie, Jane L., Ethical culture schools, New York
Hubbard, Dwight L., 117 W. 93d st., New York
Hudson, George H., Plattsburg normal school
Humphrey, O. D., Jamaica (L. I.) state normal school
Hunt, Arthur E., Manual training high school, Brooklyn
Hurd, Frances, Oneonta normal school

[1]**Jameson,** J. M., Pratt institute, Brooklyn
Jaquish, Benjamin M., Dr Sach's school, New York
Jewett, Franklin N., Fredonia normal school

[1]**Karr,** Grant, Oswego normal school
Kauffman, W. L., Yonkers high school
[1]Kelly, Henry A., Ethical culture schools, New York

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[1]Attended the Rochester meeting.

**Kelly,** Mrs H. A., Ethical culture schools, New York
Kemp, James Furman, Columbia university, New York
[1]Kenyon, O. C., Syracuse high school
Kingsbury, George H., Newtown high school, Elmhurst
Kingsley, J. Stanton, Newark Valley high school
[1]Kittredge, R. J., Schenectady union classical institute
Knapp, Allen H., Canton high school

**Langworthy,** William F., Colgate academy, Hamilton
[1]Leary, Montgomery E., Rochester atheneum and mechanics institute
[1]Lee, Frederic S., Columbia university, New York
[1]Lennon, Alice L., Brockport normal school
[1]Lennon, W. H., Brockport normal school
Lewis, Fred Z., Brooklyn boys high school
Lewis, Mrs Lucy S., girls high school, Brooklyn
[1]Linville, Henry R., DeWitt Clinton high school, New York
Lloyd, Francis E., Teachers college, New York
Loeb, Morris, New York university
[1]Logan, Mrs Mary C., Lyons high school
[1]Lovell, Thomas B., Cleveland av. high school, Niagara Falls
Lyon, Catherine E., 113 Greene place, Brooklyn
[1]Lyon, Howard, Oneonta normal school

**MacClaughry,** Mollie, Saratoga Springs
McGreevy, Thomas H., High street school no. 39, Buffalo
McKay, John S., Packer collegiate institute, Brooklyn
[1]McMurry, Frank M., Teachers college, New York
Mann, Warren, Potsdam normal school
Mar, Frederick W., Brooklyn boys high school
[1]Marcella, Sister M., Nazareth academy, Rochester
Matteson, Florence M., Oneonta normal school
Maury, Mytton, 109 Cascadilla st., Ithaca
Mead, F. L., Madison school, Syracuse
Mercer, W. F., Chamberlain institute, Randolph
[1]Merrell, William D., University of Rochester
Merrill, F. J. H., New York state museum, Albany
[1]Miller, Gertrude, Penn Yan academy
[1]Milliman, Lennette G., Rochester high school
Moler, G. S., Cornell university, Ithaca
Moore, Katherine Rowe, Dresden
[1]Morrey, William T., Peter Cooper high school, New York
Morrill, A. D., Hamilton college, Clinton
Morse, C. W., DeWitt Clinton high school, New York
Morse, H. L. F., Troy high school
[1]Moulthrop, S. P., Washington grammar school, Rochester
Murphy, Charles T., Latin school, Brooklyn

[1]**Nichols,** Edward L., Cornell university, Ithaca
[1]**Norris,** Isadora, Springville high school

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[1] Attended the Rochester meeting.

**Osborn**, Henry F., Columbia university, New York

**Paddock**, Bertha L., Franklin academy, Malone
[1]Palmer, Lelia B., Utica free academy
Pattee, Ernest N., Syracuse university
Peabody, James E., Peter Cooper high school, New York
Peck, Henry A., Syracuse university
[1]Peckham, W. C., Adelphi college, Brooklyn
Piez, Richard K., Oswego normal school
Pingrey, Mrs Cora E., Whiteplains high school
Piper, P. F., Buffalo central high school
Pollock, Horatio M., Albany high school
Proper, Emberson E., Brooklyn boys high school

**Raneson**, Edward B., Friends seminary, New York
Reed, Raymond C., New York state veterinary college, Ithaca
[1]Reynolds, Roberta, Masten Park high school, Buffalo
Rich, J. F., Batavia
Richards, Charles R., Teachers college, New York
Richards, C. W., Oswego high school
Robinson, Emma C., public school no. 4, Mount Vernon
[1]Rogers, Charles G., Syracuse university
Rogers, F. J., Cornell university, Ithaca
Rogers, Mary F., Cornell university, Ithaca
Rollins, Frank, DeWitt Clinton high school, New York
Rowlee, W. W., Cornell university, Ithaca

**Sage**, L. Belle, Olean high school
St John, Thomas M., Browning school, New York
Sampson, Ezra W., Mott av. and 144th st., New York
Sanial, Marie L., public school no. 90, New York
Schmitz, H. J., Geneseo normal school
[1]Schneider, P. F., Syracuse high school
Schüssler, Amy, Teachers college, New York
Scott, Charles B., Oswego normal school
Scribner, E. E., Dunkirk high school
Seymour, A. T., Peter Cooper high school, New York
Sharp, Clayton H., Cornell university, Ithaca
Shatz, Josephine, Rochester high school
[1]Shearer, John S., Cornell university, Ithaca
Sheldon, C. S., Oswego normal school
[1]Sherwood, Leora E., Syracuse high school
Sieberg, W. H. J., public school no. 43, New York
Sleeper, Joseph J., P. O. box 74, New York
[1]Smith, V. J., Gloversville
Spice, Robert, Cooper union, New York
Stepanek, Beatrice, Canton high school
Stocker, John H., Brooklyn boys high school

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[1] Attended the Rochester meeting.

[1]Stoller, James H., Union college, Schenectady
Stone, Anna J., school no. 13, Binghamton
Stowell, T. B., Potsdam normal school
Sweetland, Libbie, Dryden high school

**Tappan,** Frances, Oneonta normal school
[1]Tarr, Ralph S., Cornell university, Ithaca
Taylor, Joseph S., Sedgewick park, Fordham hights
Taylor, R. A., Fifth street high school, Niagara Falls
Taylor, S. N., Syracuse university
[1]Tenney, Lloyd S., Brockport normal school
[1]Thomas, M. Smith, Pike seminary
[1]Thurston, R. H., Cornell university, Ithaca
Trant, Amelia Earle, Masten Park high school, Buffalo
[1]Turner, George M., Masten Park high school, Buffalo

**Underwood,** L. M., Columbia university, New York

**Van Arsdale,** May B., Teachers college, New York
Vogt, Frederick A., Buffalo central high school
Von Nardroff, C. R., Erasmus Hall high school, Brooklyn
Vosburgh, Charles H., Jamaica L. I.
Vulté, H. T., Columbia university, New York

**Ward,** Charles H., Ward's natural science establishment, Rochester
Ward, Delancey W., 215 W. 42d st., New York
[1]Warner, A. R., Auburn high school
[1]Webb, Harry E., Pratt institute, Brooklyn
Weed, Henry T., Manual training high school, Brooklyn
Wetmore, Edward W., New York state normal college, Albany
Wetmore, Katherine S., Rochester high school
[1]Wheelock, Charles F., Regents office, Albany
White, T. G., Columbia university, New York
Whitney, E. R., Binghamton high school
[1]Wilber, T. C., Waterloo high school
[1]Wilcox, C. C., Starkey seminary, Eddytown
Wilder, Burt G., Cornell university, Ithaca
Willard, A. Blanche, Waterville high school
Williston, Arthur L., Pratt institute, Brooklyn
Wilson, John D., Putnam school, Syracuse
Wilson, Victor T., Cornell university, Ithaca
[1]Wixom, F. C., Penn Yan academy
[1]Wolcott, H. G., Clifton Springs union and classical school
Woodhull, John F., Teachers college, New York
Woodland, J. E., Cook academy, Montour Falls
Wyckoff, Adelaide E., Packer collegiate institute, Brooklyn

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[1] Attended the Rochester meeting.

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## OTHERS WHO REGISTERED AT THE MEETING

Britt, W. Warren, Leroy high school
Chriswell, W. B., Hamburg high school
Fairchild, J. R., New York
Herrick, Millian B., Amsterdam high school
Heyl, Fredrika M., The Balliol school, Utica
Johnson, J. B., University of Wisconsin
Pre, George W., grammar school no. 5, Rochester
Queen, John J., Warren high school
Smith, G. W., 143 Liberty st., New York
Whitbeck, R. H., Cornell university, Ithaca

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Till 1894 these reports formed part of the general University reports, known as the regents reports. They cover courses of study in secondary schools, examination of professional and business students, licensing examinations for physicians, dentists, veterinary surgeons and certified public accountants. *See also* B23.

In 1898 the examination reports and bulletins were discontinued and replaced by those of the college and high school departments into which the examination department was reorganized.

**Examination bulletins.** University of the State of New York—Examination dep't. Bulletins. O. Albany 1895–98. *Price to advance subscribers* 50 *cents a year.*

**B4** (Examinations 1) Regents examinations. 82p. Nov. 1890. *Price* 10 *cents.*

Historical sketch, laws, ordinances and rules pertaining to all examinations conducted by the regents; details as to all University credentials; subjects, times and places of examinations 1891-95; notes on the reorganization of 1890.

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**B10** (Examinations 3) Medical syllabus. 30p. Oct. 1892. *Replaced by* X7.

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Outline of ground covered by examinations for the regents degree of bachelor of laws.

**B23** (Examinations 5) Report of examination department 1893. 82p. Feb. 1894. *Price* 10 *cents.*

**X6** Report of examination department 1894. 126p. Mar. 1895. *Price* 15*c.*

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**X23** (High school 7) State science teachers association. Proceedings of the fourth annual meeting, Dec. 1899. 302p. May 1900. *Price 35 cents.*

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The University declines to recommend any special textbook, but for the guidance of teachers and students it specifies the ground covered by each of the preliminary and academic subjects. This syllabus is the best available outline of what should be accomplished in these subjects.

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